RMC Surveying

THE

THEORY AND PRACTICE

OF

SURVEYING;

CONTAINING

All the Instructions requisite for the skilful practice of this Art.

BY

ROBERT GIBSON.

ILLUSTRATED BY COPPER-PLATES:

THE

WHOLE CORRECTED, NEWLY ARRANGED, AND GREATLY ENLARGED;

WITH USEFUL SELECTIONS,

AND A NEW SET OF ACCURATE

MATHEMATICAL TABLES.

By D. P. ADAMS,

TEACHER OF THE MATHEMATICS.

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EXPLANATION

Of the Mathematical Characters used in this Work.

$+$ signifies *plus*, or addition.

$-$ . . *minus*, or subtraction.

$\times$ *or* . , . multiplication.

$\div$ . . division.

$: \; : : \; :$. proportion.

$=$ . . equality.

$\surd$ . . square root.

$\sqrt[3]{}$ . . cube root, &c.

$\backsim$ . . diff. between two numbers when it is not known which is the greater.

Thus,

$5 + 3$, denotes that 3 is to be added to 5.

$6 - 2$, denotes that 2 is to be taken from 6.

7×3, or $7 . 3$, denotes that 7 is to be multiplied by 3.

$8 \div 4$, denotes that 8 is to be divided by 4.

$2 : 3 : : 4 : 6$, shows that 2 is to 3 as 4 is to 6.

$6 + 4 = 10$, shows that the sum of 6 and 4 is equal to 10.

$\surd 3$, or $3^{\frac{1}{2}}$, denotes the square root of the number 3.

$\sqrt[3]{5}$, or $5^{\frac{1}{3}}$, denotes the cube root of the number 5.

7^2, denotes that the number 7 is to be squared.

8^3, denotes that the number 8 is to be cubed.

&c.

THE THEORY AND PRACTICE OF SURVEYING.

THE word Surveying, in the Mathematics, signifies the art of measuring land, and of delineating its boundaries on a map.

The Surveyor, in the practice of this art, directs his attention, at first, to the tracing and measuring of lines; secondly, to the position of these lines in respect to each other, or the angles formed by them; thirdly, to the plan, or representation of the field, or tract, which he surveys; and fourthly, to the calculation of its area, or superficial content. When this art is employed in observing and delineating Coasts and Harbours, in determining their variation of the Compass, their Latitude, Longitude and soundings, together with the bearings of their most remarkable places from each other, it is usually denominated Maritime Surveying. This branch of Surveying, however, demands no other qualifications than those, which should be thoroughly acquired by every Land-Surveyor, who aspires to the character of an accomplished and skilful practitioner. Surveying, therefore, requires an intimate acquaintance with the several parts of the Mathematics, which are here inserted as an introduction to this treatise.

PART I.

Containing Decimal Fractions, Involution and Evolution, the Nature and Use of Logarithms, Geometry and Plane Trigonometry.

SECTION I.

DECIMAL FRACTIONS.

If we suppose unity or any one thing to be divided into any assigned number of equal parts, this number is called the denominator; and if we chuse to take any number of such parts less than the whole, this is called the numerator of a fraction.

The numerator, in the vulgar form, is always written over the denominator, and these are separated by a small line thus $\frac{3}{4}$, or $\frac{5}{8}$; the first of these is called three-fourths, and the latter five-eighths of an inch, yard, &c. or of whatever the whole thing originally consisted: the 4 and the 8 are the denominators, showing into how many equal parts the unit is divided; and the three and the five are the numerators, showing how many of those parts are under consideration.

Fractions are expressed in two forms, that is, either vulgarly or decimally.

All fractions whose denominators do not consist of a cipher, or ciphers, set after unity, are called vulgar; and their denominators are always written under their numerators. The treatment of these, however, would be foreign to our present purpose. But fractions whose denominators consist of an unit prefixed to one or more ciphers, are called decimal fractions; the numerators of which are written without their denominators, and are distinguished from integers by a point prefixed: thus $\frac{2}{10}$, $\frac{42}{100}$ and $\frac{172}{1000}$, in the decimal form, are expressed by .2 .42 .172.

The denominators of such fractions consisting always of an unit, prefixed to as many ciphers as there are places of figures in the numerators, it follows, that any number of ciphers put after those numerators, will neither increase nor lessen their value: for $\frac{3}{10}$, $\frac{30}{100}$ and $\frac{300}{1000}$ are all of the same value, and will stand in the decimal form thus .3 .30 .300; but a cipher, or ciphers prefixed to those numerators lessen their value in a tenfold proportion: for $\frac{3}{10}$, $\frac{03}{100}$ and $\frac{003}{1000}$, which in the decimal form we denote by .3 .03 and .003, are fractions, of which the first is ten times greater than the second; and the second, ten times greater than the third.

Hence it appears, that as the value and denomination of any figure, or number of figures, in common arithmetic is enlarged, and becomes ten, or an hundred, or a thousand times greater, by placing one or two, or three ciphers after it; so in decimal arithmetic, the value of any figure, or number of figures, decreases, and becomes ten, or a hundred, or a thousand times less, while the denomination of it increases, and becomes so many times greater, by prefixing one, or two, or three ciphers to it: and that any number of ciphers, before an integer, or after a decimal fraction, has no effect in changing their values.

SCALE OF NOTATION.

Integers.		Decimals.	
7	millions.	8	tenth parts.
3	hundred thousands.	7	hundredth parts.
4	ten thousands.	5	thousandth parts.
2	thousands.	3	ten thousandth parts.
1	hundreds.	2	hundred thousandth parts.
8	tens.	6	millionth parts.
6	units.		

ADDITION OF DECIMALS.

Write the numbers under each other according to the value or denomination of their places; which position will bring all the Decimal points into a column, or vertical line, by themselves. Then, beginning at the right hand column of figures, add in the same manner as in whole numbers, and put the decimal point, in the sum directly beneath the other points.

EXAMPLES.

Add 4.7832 3.2543 7.8251 6.03 2.857 and 3,251 together. Place them thus,

4.7832
3.2543
7,8251
6,03
2.857
3.251

―――――

Sum=28,0006.

Add 6.2 121.306 .75 2.7 and .0007 together.

```
       121.306
          .75
         2.7
          .0007
      --------
Sum = 130.9567
      --------
```

What is the sum of 6.57 1.026 .75 146.5 8.7 526. 3.97 and .0271 ?

Answer 693.5431.

What is the sum of 4.51 146.071 .507 .0006 132. 62.71 .507 7.9 and .10712 ?

Answer 354.31272.

SUBTRACTION OF DECIMALS.

Write the figures of the subtrahend beneath those of the minuend according to the denomination of their places, as directed in the rule of addition; then, beginning at the right hand, subtract as in whole numbers, and place the decimal point in the difference exactly under the other two points.

EXAMPLES.

From 38.765 take 25.3741

```
              25.3741
             --------
Difference = 13.3909
             --------
```

From 2.4 take .8472

```
          .8472
        -------
Diff. = 1.5528
        -------
```

From 71.45 take 8.4837248.
Difference = 62.9662752.
From 84 take 82.3412.
Diff. = 1.6588.

MULTIPLICATION OF DECIMALS.

Set the multiplier under the multiplicand without any regard to the situation of the decimal point; and having multiplied as in whole numbers, cut off as many places for decimals in the product, counting from the right hand towards the left, as there are in both the multiplicand and multiplier: but if there be not a sufficient number of places in the product, the defect may be supplied by prefixing ciphers thereto.

For the denominator of the product being an unit, prefixed to as many ciphers, as the denominators of the multiplier and multiplicand contain of ciphers, it follows, that the places of decimals in the product, will be as many as in the numbers from whence it arose.

EXAMPLES.

```
Multiply 48.765 by .003609
                   .003609
                   -------
                    438885
                   292590
                  146295
         -----------------
Product=.175992885

Multiply .121
      by .14
         ----
          484
         121
         ----
Product=.01694
```

$$
\begin{array}{r}
\text{Multiply } 121.6 \text{ by } 2.76 \\
2.76 \\
\hline
7296 \\
8512 \\
2432 \\
\hline
\text{Product} = 335.616 \\
\hline
\end{array}
$$

Multiply .0089789 by 1085
Product = 9.7421065

Multiply .248723 by .13587
Product = .03379399401.

DIVISION OF DECIMALS.

Divide as in whole numbers; observing that the divisor and quotient together must contain as many decimal places as there are in the dividend. If, therefore, the dividend have just as many places of decimals as the divisor has, the quotient will be a whole number without any decimal figures. If there be more places of decimals in the dividend, than there are in the divisor, point off as many figures in the quotient for decimals, as the decimal places in the dividend exceed those in the divisor; the want of places in the quotient being supplied by prefixing ciphers. But if there be more decimal places in the divisor, than in the dividend, annex ciphers to the dividend, so that the decimal places here may be equal, in number, to those in the divisor; and then the quotient will be a whole number, without fractions.

When there is a remainder, after the division has been thus performed, annex ciphers to this remainder, and continue the operation till nothing remains, or till a sufficient number of decimals shall be found in the quotient.

EXAMPLES.

Divide .144 by .12

```
.12).144(1.2 = quotient.
     12
     --
      24
      24
      --
       0
```

Divide 63.72413456922 by 2718

```
2718)63.72413456922(.02344522979 = quotient.
     5436
     ----
      9364
      8154
      -----
      12101
      10872
      -----
       12293
       10872
       -----
        14214
        13590
        -----
          6245
          5436
          -----
           8096
           5436
           -----
           26609
           24462
           -----
            21472
            19026
            -----
             24462
             24462
             -----
                 0
```

There being 11 decimal figures in the dividend, and none in the divisor, 11 figures are to be cut off in the quotient; but as the quotient itself consists of but 10 figures, prefix to them a cipher to complete that number.

Divide 1.728 by .012

```
.012)1.728(144=quotient.
      12
     ---
      52
      48
     ---
       48
       48
      ---
        0
```

Because the number of decimal figures in the divisor and dividend, are alike, the quotient will be integers.

Divide 2 by 3.1416

```
3.1416)2.0000,0(0.636618+=quotient.
       1 8849 6
       --------
        115040
         94248
        -------
         207920
         188496
         -------
          194240
          188496
          -------
            57440
            31416
           -------
           260240
           251228
           -------
             9012+
```

In this example there are four decimal figures in the divisor, and none in the dividend; therefore, according to the rule, four ciphers are annexed to the dividend, which in this condition, is yet less than the divisor. A cipher must then be put in the quotient, in the place of integers, and other ciphers annexed to the dividend; and the division being now performed, the decimal figures of the quotient are obtained.

Divide 7234.5 by 6.5 Quotient=1113.
Divide 476.520 by .423 ———=1126.5+
Divide .45695 by 12.5 ———=.0365+
Divide 2.3 by 96 ———=.02395+
Divide 87446071 by .004387 —=19933000000.
Divide .624672 by 482 ———=.001296.

REDUCTION OF DECIMALS.

RULE I.

To reduce a Vulgar Fraction to a Decimal of the same value.

Having annexed a sufficient number of ciphers, as decimals, to the numerator of the vulgar fraction, divide by the denominator; and the quotient thence arising, will be the decimal fraction required.

EXAMPLES.

Reduce $\frac{3}{4}$ to a decimal fraction.

4)3.00

.75=decimal required.

For $\frac{3}{4}$ of one acre, mile, yard, or any thing, is equal to $\frac{1}{4}$ of 3 acres, miles, yards, &c. there-

fore if 3 be divided by 4, the quotient is the answer required.

Reduce $\frac{2}{5}$ to a decimal fraction. Answer .4

Reduce $\frac{12}{25}$ - - - - .48

Reduce $\frac{25}{218}$ - - - - .1146789

Reduce $\frac{7}{9}$ - - - - .7777+

Reduce $\frac{21}{23}$ - - - - .9130434+

Reduce $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, and so on to $\frac{1}{10}$, to their corresponding decimal fractions; and in this operation the various modes of interminate decimals may be easily observed.

RULE II.

To reduce Quantities of the same, or of different Denominations to Decimal Fractions of higher denominations.

If the given quantity consist of one denomination only, write it as the numerator of a vulgar fraction; then consider how many of this make one of the higher denomination, mentioned in the question, and write this latter number under the former, as the denominator of a vulgar fraction. When this has been done, divide the numerator by the denominator, as directed in the foregoing rule, and the quotient resulting will be the decimal fraction required.

But if the given quantity contain several denominations, reduce them to the lowest term for the numerator; reduce likewise that quantity, whose fraction is sought, to the same denomination for the denominator of a vulgar fraction; then divide as before directed.

EXAMPLES.

Reduce 9 inches to the Decimal of a foot.

The foot being equal to 12 inches, the vulgar fraction will be $\frac{9}{12}$; then 12)9.00

.75=decimal fraction required.

Reduce 8 inches to the decimal of a yard.

$$\frac{8 \text{ inches.}}{1 \text{ yard} \times 3 \times 12 = 36 \text{ inches.}}$$

36)8.0(.22 + = Answer.
72

80
72

8

Reduce 5 furlongs 12 perches to the decimal of a mile.

1 mile	5 furlongs
8	40
8 fur.	200
40	$\frac{200}{320}$ = vulgar fraction.
320 per.	

320)200.0(.625 = decimal sought.
1920

800
640

1600
1600

Reduce 21 minutes 54 seconds to the decimal of a degree. Ans. .365

Reduce .056 of a pole to the decimal of an Acre, Ans. .00035

Reduce 13 cents to the decimal of an Eagle. Ans. .013

Reduce 14 minutes to the decimal of a day. Ans. .00972+

Reduce 3 hours 46 minutes to the decimal of a week. Ans. .0224206+

RULE III.

To find the value of Decimal Fractions in terms of the lower denominations.

Multiply the given decimal by the number of the next lower denomination, which makes an integer of the present, and point off as many places at the right hand of the product, for a remainder, as there are figures in the given decimal. Multiply this remainder by the number of the next inferior denomination, and point off a remainder, as before. Proceed in this manner through all the parts of the integer, and the several denominations, standing on the left hand, are the value required.

EXAMPLES.

Required the value of .3375 of an acre.

$$\begin{array}{r l} .3375 & \\ 4 & = \text{number of roods [in an acre.} \\ \hline 1.3500 & \\ 40 & = \text{number of perches [in a rood.} \\ \hline 14.0000 & \end{array}$$

The value, therefore, is 1 rood 14 perches.

What is the value of .6875 of a yard?

```
      3=number of feet in a
 ------                [yard.
2.0625
     12=number of inches in
 ------              [a foot.
 .7500
     12=number of lines in
 ------             [an inch.
9.0000
```

The answer here is 2 feet 9 lines.

What is the value of .084 of a furlong? Ans. 3 per. 1 yd. 2 ft. 11 in.

What is the value of .683 of a degree? Ans. 40 m. 58 sec. 48 thirds.

What is the value of .0053 of a mile? Ans. 1 per. 3 yds. 2 ft. 5 in.+

What is the value of .036 of a day? Ans. 51′ 50″ 24‴.

PROPORTION

IN DECIMAL FRACTIONS.

Having reduced all the fractional parts in the given quantities to their corresponding decimals, and having stated the three known terms, so that the fourth, or required quantity, may be as much greater, or less than the third, as the second term is greater, or less than the first, then multiply the second and third terms together, and divide the product by the first term, and the quotient will be the answer;—in the same denomination with the third term.

EXAMPLES.

If 3 acres 3 roods of land can be purchased for 93 dollars 60 cts. how much will 15 acres 1 rood cost at that rate?

3 acs. 3 rds. = 3.75 acres.
15 acs. 1 rd. = 15.25 acres.
$93 , 60 cts. = $93.60
Then 3.75 : 15.25 : : 93.60 :
15.25

46800
18720
46800
9360

$
3.75)1427.4000(380.64=Answer.
1125

3024
3000

2400
2250

1500
1500

If a clock gain 14 seconds in 5 days 6 hours, how much will it gain in 17 days 15 hours? Ans. 47 seconds.

If 187 dollars 85 cents gain 12 dollars 33 cents interest in a year, at what rate per cent is this interest? Ans. 6.56+

SECTION II.

INVOLUTION AND EVOLUTION.

Involution is the method of raising any number, considered as the root, to any required power.

Any number, whether given, or assumed at pleasure, may be called the root, or first power of this number; and its other powers are the products, that result from multiplying the number by itself, and the last product by the same number again; and so on to any number of multiplications.

The index, or exponent, is the number donoting the height, or degree of the power, being always greater by one, than the number of multiplications employed in producing the power It is usually written above the root, as in the following EXAMPLE, where the method of involution is plainly exhibited.

Required the fifth power of 8 } = the root, or first
first multiply by - - 8 } power.

then multiply the product 64 = 8^2 = square, or
by 8 [second power.

&c. 512 = 8^3 = cube, or
8 [third power.

4096 = 8^4 = biquadrate
8 [or fourth power.

32768 = 8^5 = Answer.

EXAMPLES FOR EXERCISE.

What is the second power of 3.05? Ans. 9.3025
What is the third power of 85.3? Answer, 620650.477
What is the fourth power of .073? Answer, 090028398241
What is the eighth power of .09? Answer, .00.00.00.0043046721

Note. When two, or more powers are multiplied together, their product is that power, whose index is the sum of the indices of the factors, or powers multiplied.

EVOLUTION is the method of extracting any required root from any given power.

Any number may be considered as a power of some other number; and the required root of any given power is that number, which, being multiplied into itself a particular number of times, produces the given power; thus if 81 be the given number, or power, its square, or second root, is 9; because $9\times9=9^2=81$; and 3 is its biquadrate, or fourth root, because $3\times3\times3\times3=3^4=81$. Again, if 729 be the given power, and its cube root be required, the answer is 9, for $9\times9\times9=729$; and if the sixth root of that number be required, it is found to be 3, for $3\times3\times3\times3\times3\times3=729$.

The required power of any given number, or root, can always be obtained exactly, by multiplying the number continually into itself; but there are many numbers, from which a proposed root can never be completely extracted;—yet by approximating with decimals, these roots may be found as exact as necessity requires. The roots that are found complete, are denominated *rational* roots, and those, which cannot be found completed, or which only approximate, are called *surd*, or irrational roots.

Roots are usually represented by these characters or exponents;

$\sqrt{}$, or $^{\frac{1}{2}}$ which signifies the square root; thus,

$\sqrt{9}$, or $9^{\frac{1}{2}}=3$

$\sqrt[3]{}$ or $^{\frac{1}{3}}$ cube root; $\sqrt[3]{64}$, or $64^{\frac{1}{3}}=4$

$\sqrt[4]{}$, or $^{\frac{1}{4}}$ biquadrate root; $\sqrt[4]{16}$, or $16^{\frac{1}{4}}=2$ &c.

Likewise $8^{\frac{3}{2}}$ signifies the square root of 8 cubed; and, in general, the fractional indices imply, that the given numbers are to be raised to such powers as are denoted by their numerators, and that such roots are to be extracted from these powers, as are denoted by their denominators.

RULE

For extracting the Square Root.

Separate the given number into periods of two figures, by putting a point over the place of units, another over the place of hundreds, and so on, over every second figure, both toward the left hand in whole numbers, and toward the right hand in the Decimal places.—When the number of integral places is odd, the first, or left hand period, will consist of one figure only.

Find the greatest square in the first period on the left hand, and write its root on the right hand of the given number, in the manner of a quotient figure in division.

Subtract the square, thus found, from the said period, and to the remainder annex the two figures of the next following period, for a dividend.

Double the root above mentioned for a divisor, and find how often it is contained in the said dividend, exclusive of its right hand figure, and set this quotient both in the place of the quotient and in the divisor.—The best way of doubling the root, to form each new divisor, is to add the last figure always to the last divisor, as it is done in the subsequent examples.

Multiply the whole augmented divisor by this last quotient figure, and subtract the product from the said dividend, bringing down to it the next period of the given number for a new dividend.

Repeat the same operation again; that is, find another new divisor, by doubling all the figures now found in the root; from which, and the last dividend, find the next figure of the root as before; and so on through all the periods to the last.

Note 1. After the figures belonging to the given number are all exhausted, the operation may be continued in decimals, by annexing any number of periods or ciphers to the remainder.

2. The number of integral places in the root, is always equal to the number of periods in the integral part of the resolvend.

3. When vulgar fractions occur in the given power, or number, they may be reduced to decimals, then the operation will be the same as before dictated.

EXAMPLES.

Required the square root of 1710864.

1	1710864(1308,=Answer.
1	1
23	71
3	69
2608	20864
	20864

Required the square root of 16007.3104.

1	16007.3104(126.52=Answer.
1	1
22	60
2	44
246	1607
6	1476
2525	13131
5	12625
25302	50604
	50604

EXAMPLES FOR EXERCISE.

Required the square root of 298116. Ans. 546.
Required the square root of 348.17320836. Ans. 18.6594.
Required the square root of 17.3056. Ans. 4.16.
Required the square root of .000729. Ans. .027.
Required the square root of $17\frac{3}{8}$. Ans. 4.168333+

A GENERAL RULE

For extracting any Root whatever.

Find by trial a number, which, when involved to the power denoted by the index of the required root, shall come nearest to the given number, whether greater or less; and let that number be called the assumed root, and when thus involved, the assumed power.

Let the given power, or number be represented by $\Big\}$ G.
the index, or exponent, in the question by X.
the assumed power, by A.
the assumed root, by Q.
and the required root by R.

Then $\overline{X+1}\times A+\overline{X-1}\times G:\overline{X+1}\times G+\overline{X-1}\times A$ $::Q:R.$

That is, as the sum of X+1 times A and X—1 times G,

is to the sum of X+1 times G and X—1 times A,

so is the assumed root, Q,

to the required root, R,—nearly; and the operation may be repeated as many times as we chuse, by using always the root last found for the assumed root, and this, involved according to the given index, for the assumed power.*

EXAMPLES.

1. Required the Cube root of 789.

* "This is a very general approximating rule," says Dr. Hutton, "of which that for the cube root is a particular case, and is the best adapted for practice and for memory, of any that I have yet seen. It was first discovered in this form by myself, and the investigation and use of it were given at large in my Tracts—page 45 &c."

Here $G=789$, $X=3$, $Q=9$, $A=9^3=729$, $\overline{X+1}=4$ and $\overline{X-1}=2$.

And $4\times729=2916$ $4\times789=3156$
$2\times789=1578$ $2\times729=1458$

Then $4494 : 4614 :: 9 : 9.240+$

$$\begin{array}{r}
4614 \\
9 \\
\hline
4494)41526(9.2403+ \text{[Ans.} \\
40446 \\
\hline
10800 \\
8988 \\
\hline
18120 \\
17976 \\
\hline
14400 \\
13482 \\
\hline
918 \ \&c.
\end{array}$$

In the foregoing example the answer is strictly correct in its integral part and also in the three first decimal places; but if more decimals were wanted, and if their exactness were likewise requisite, the present answer might be taken for the assumed root, and the whole operation should be repeated.

2. Required the biquadrate root of 2.0743.

Here $G=2.0743$, $Q=1.2$, $A=\overline{1.2}^4=2.0736$, $X=4$, $\overline{X+1}=5$, and $\overline{X-1}=3$.

And $5\times2.0736=10.3680$ $5\times2.0743=10.3715$
$3\times2.0743=\ \ 6.2229$ $3\times2.0736=\ \ 6.2208$

Then $16.5909 : 16.5923 :: 1.2 : 1.2001+$ [Ans.

Required the fifth root of 21035.8 Ans. =7.3213±
Required the sixth root of 21035.8 Ans. =5.2540+
Required the cube root of 999 Ans. =9.9966+
Required the fourth root of 97.41 Ans. =3.1416
Required the cube root of .037 Ans. =.33322+
Required the cube root of 2 Ans. =1.2599+
Required the seventh root of 21035.8 Answer= [4.1454.

SECTION III.

OF LOGARITHMS.

Logarithms are a series of numbers, so contrived, that by them the work of multiplication may be performed by addition; and the operation of division may be done by subtraction. Or,—Logarithms are the indices, or series of numbers in arithmetical progression, corresponding to another series of numbers in geometrical progression. Thus,

$\begin{cases} 0, 1, 2, 3, 4, 5, 6, \&c. \text{ Indices or Logarithms.} \\ 1, 2, 4, 8, 16, 32, 64, \&c. \text{ Geometrical progression.} \end{cases}$

Or,

$\begin{cases} 0, 1, 2, 3, 4, 5, 6, \&c. \text{ Ind. or Log.} \\ 1, 3, 9, 27, 81, 243, 729, \&c. \text{ Geometrical Series.} \end{cases}$

Or,

$\begin{cases} 0, 1, 2, 3, 4, 5, 6, \&c. \text{I.orL.} \\ 1, 10, 100, 1000, 10000, 100000, 1000000, \&c. \end{cases}$

Geometrical series,—where the same indices serve equally for any Geometrical series, or progression.

Hence it appears that there may be as many kinds of indices, or logarithms, as there can be taken kinds of geometrical series. But the Logarithms most convenient for common uses are those

adapted to a geometrical series increasing in a ten-fold progression, as in the last of the foregoing examples.

In the geometrical series 1, 10, 100, 1000, &c. if between the terms 1 and 10, the numbers 2, 3, 4, 5, 6, 7, 8, 9 were interposed, indices might also be adapted to them in an arithmetical progression, suited to the terms interposed between 1 and 10, considered as a geometrical progression. Moreover, proper indices may be found to all the numbers, that can be interposed between any two terms of the Geometrical series.

But it is evident that all the indices to the numbers under 10, must be less than 1; that is, they must be fractions. Those to the numbers between 10 and 100, must fall between 1 and 2; that is, they are mixed numbers, consisting of 1 and some fraction. Likewise the indices to the numbers between 100 and 1000, will fall between 2 and 3; that is, they are mixed numbers, consisting of 2 and some fraction; and so of the other indices.

Hereafter the integral part only of these indices will be called the Index; and the fractional part will be called the Logarithm. The computation of these fractional parts, is called *making Logarithms;* and the most troublesome part of this work is to make the Logarithms *of Prime Numbers,* or those which cannot be divided by any other numbers than themselves and unity.

RULE

For Computing the Logarithms of Numbers.

Let the sum of its proposed number and the next less number be called A. Divide 0.8685889638×†

† The number 0.8685889638+ is the quotient of 2 divided by 2.302585093, which is the logarithm of 10, according to the first

by A, and reserve the quotient. Divide the reserved quotient by the square of A, and reserve this quotient. Divide the last reserved quotient by the square of A, reserving the quotient still; and thus proceed as long as division can be made. Write the reserved quotients orderly under one another, the first being uppermost. Divide these quotients respectively by the odd numbers 1, 3, 5, 7, 9, 11, &c.; that is, divide the first reserved quotient by 1, the second by 3, the third by 5, the fourth by 7, &c. and let these quotients be written orderly under one another; add them together, and their sum will be a logarithm. To this logarithm add the logarithm of the next less number, and the sum will be the logarithm of the number proposed.

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form of Lord Napier, the inventor of logarithms. The manner in which Napier's logarithm of 10 is found, may be seen in most books of Algebra, but it is here omitted, because students of Surveying are too generally unacquainted with the principles of that science, and the subject is too extensive for the present treatise. Those, however, who have not an opportunity for entering thoroughly into this subject, may with more propriety grant the truth of one number, and thereby be enabled to try the correctness of any logarithm in the tables, than receive those tables, as truly computed, without any means of examining their accuracy.

EXAMPLE I.

Required the Logarithm of the number 2.

Here the next less number is 1, and $2+1=3=$ A. and A^2, or $3^2=9$; then

$$
\begin{array}{l}
3)0.868588964 \\
\hline
9)0.289529654 \div 1 = 0.289529654 \\
\hline
9)0.032169962 \div 3 = 0.010723321 \\
\hline
9)0.003574440 \div 5 = 0.000714888 \\
\hline
9)0.000397160 \div 7 = 0.000056737 \\
\hline
9)0.000044129 \div 9 = 0.000004903 \\
\hline
9)0.000004903 \div 11 = 0.000000446 \\
\hline
9)0.000000545 \div 13 = 0.000000042 \\
\hline
\quad 0.000000061 \div 15 = 0.000000004 \\
\end{array}
$$

To this Logarithm 0.301029995
add the Logarithm of 1 = 0.000000000

Their Sum = 0.301029995 = Log. of 2.

The manner in which the division is here carried on, may be readily perceived by dividing, in the first place, the given decimal by A, and the succeeding quotients by A^2; then letting these quotients remain in their situation, as seen in the example, divide them respectively by the odd numbers, and place the new quotients in a column by themselves. By employing this process, the operation is considerably abbreviated.

EXAMPLE 2.

Required the Logarithm of the number 3.

Here the next less number is 2; and $3+2\ 5=A$, and $A^2=25$.

5)0.868588964

25)0.173717793 ÷ 1 = 0.173717793

25)0.006948712 ÷ 3 = 0.002316237

25)0.000277948 ÷ 5 = 0.000055599

25)0.000011118 ÷ 7 = 0.000001588

25)0.000000445 ÷ 9 = 0.000000049

0.000000018 ÷ 11 = 0.000000002

To this Logarithm 0.176091259
add the Logarithm of 2 = 0.301029995

Their Sum = 0.477121254 = Log. of 3.

Then, because the sum of the logarithms of numbers, gives the logarithm of their product; and the difference of the logarithms, gives the logarithm of the quotient of the numbers: from the two preceding logarithms, and the logarithm of 10, which is 1, a great many logarithms can be easily made, as in the following examples.

Example 3. Required the Logarithm of 4.

Since $4=2\times2$, then to the Logarithm of
2 = 0.301029995
add the Logarithm of 2 = 0.301029995

The sum = Logarithm of 4 = 0.602059990

Example 4. Required the Logarithm of 5.

10÷2 being=5, therefore from the Log. of
10=1.000000000
subtract the Log. of 2=0.301029995

the remainder is the Log. of 5=0.698970005

Example 5. Required the Logarithm of 6.

6=3×2, therefore to the Logarithm of
3=0.477121254
add the Logarithm of 2=0.301029995

their sun=Log. of 6=0.778151249

Example 6. Required the Logarithm of 8.

$8=2^3$, therefore multiply the Logarithm of
2=0.301029995
by 3

The product=Log. of 8=0.903089985

Example 7. Required the Logarithm of 9.

$9=3^2$, therefore the Logarithm of
3=0.477121254
being multiplied by 2

the product=Log. of 9=0.954242508

Example 8. Required the Logarithm of 7.

Here the next less number is 6, and $7+6=13=$ A, and $A^2=169$.

13)0.868588964

169)0.066814536÷1=0.066814536

169)0.000395352÷3=0.000131784

169)0.000002339÷5=0.000000468

0.000000014÷7=0.000000002

To this Logarithm=0.066946790
add the Log. of 6=0.778151249

Their sum=0.845098039=Log. of 7.

The Log.	of 12	is equal to the sum of the Logs.	of 3 and 4.
	of 14		of 7 and 2.
	of 15		of 3 and 5.
	of 16		of 4 and 4.
	of 18		of 3 and 6.
	of 20		of 4 and 5.

The Logarithms of the prime numbers, 11, 13, 17, 19, &c. being computed by the foregoing general Rule, the Logarithms of the intermediate numbers are easily found by composition and division. It may, however, be observed, that the operation is shorter in the larger prime numbers; for when any given number exceeds 400, the first quotient, being added to the Logarithm of its next lesser number, will give the Logarithm sought, true to 8, or 9 places; and therefore it will be very easy to examine any suspected Logarithm in the Tables.

For the arrangement of Logarithms in a Table, the method of finding the Logarithm of any natural number, and of finding the natural number corres-

ponding to any given Logarithm, therein: likewise for particular rules concerning the Indices, the reader will consult Table 1, with its explanation, at the end of this Treatise.

MULTIPLICATION,

Two, or more numbers being given, to find their product by Logarithms.

RULE.

Having found the Logarithms of the given numbers in the Table, add them together, and their sum is the Logarithm of the product; which Logarithm, being found in the Table, will give a natural number, that is, the product required.

Whatever is carried from the decimal part of the Logarithm is to be added to the affirmative indices; but subtracted from the negative. Likewise the indices must be added together, when they are all of the same kind, that is, when they are all affirmative, or all negative; but when they are of different kinds, the difference must be found, which will be of the same denomination with the greater.

Example 1. Required the product of 86.25 multiplied by 6.48

Log. of 86.25=1.935759
Log. of 6.48=0.811575

Product=558.9=2.747334

Example 2. Required the product of 46.75 and .3275

Log. of 46.75= 1.669782
Log. of .3275=—1.515211

Product = 15.31+ = 1.184993

Example 3. Required the product of 3.768, 2.053 and .007693.

Log. of 3.768= 0.576111
Log. of 2.053= 0.312389
Log. of .007693=—3.886096

Product=.05951× =—2.774596

Example 4. Required the product of 27.63, 1.859, .7258 and 0.3591.

Log. of 27.63 = 1.441381
Log. of 1.859= 0.269279
Log. of .7258 =—1.860817
Log. of .03591=—2.555215

Product nearly=1.339 = 0.126692

DIVISION.

Two numbers being given, to find how many times one is contained in the other, by Logarithms.

RULE.

From the Logarithm of the Dividend subtract the Logarithm of the Divisor, and the remainder will be the Logarithm, whose corresponding natural number will be the Quotient required.

In this operation, the Index of the Divisor must be changed from affirmative to negative, or from negative to affirmative; and then the difference of the affirmative and negative Indices must be taken for the index to the Logarithm of the Quotient. Likewise when one has been borrowed in the left hand place of the Decimal part of the Logarithm, add it to the Index of the Divisor, if affirmative; but subtract it, if negative; and let the

Index, thence arising, be changed and worked with, as before.

Example 1. Divide 558.9 by 6.48.
Log. of 558.9 =2.747334
Log. of 6.48 =0.811575

Quotient = 86.25 =1.935759

Example 2. Divide 15.31 by 46.75.
Log. of 15.31= 1.184975
Log. of 46.75= 1.669782

Quotient=.3275=—1.515193

Example 3. Divide .05951 by .007693.
Log. of .05951 =—2.774590
Log. of .007693=—3.886096

Quotient=7.735 = 0.888494

Example 4. Divide .6651 by 22.5.
Log. of .6651=—1.822887
Log. of 22.5 = 1.352183

Quotient=.02956=—2.470704

PROPORTION,

Or the Rule of Three in Logarithms.

RULE.

Having stated the three given terms according to the rule in common Arithmetic, write them orderly under one another, with the signs of proportion; then add the Logarithms of the second and third terms together, and from their sum subtract

the Logarithm of the first term, and the remainder will be the Logarithm of the fourth term, or Answer.

Or,—add together the Arithmetical Complement of the Logarithm of the first term, and the Logarithms of the second and third terms; the sum, rejecting 10 from the index, will be the Logarithm of the fourth term, or term required.

N. B. The Arithmetical Complement of a Logarithm is what it wants of 10,000000, or 20,000000, and the easiest way to find it is to begin at the left hand, and subtract every figure from 9, except the last, which should be taken from 10; but if the index exceed 9, it must be taken from 19.—It is frequently used in the rule of Proportion and Trigonometrical calculations, to change Subtractions into Additions.

EXAMPLES.

1st. *If a clock gain 14 seconds in 5 days 18 hours, how much will it gain in 17 days 15 hours?*

5.75 days	: Log.=	0.759668
17.625 days	: : Log.=	1.246129
14 Seconds	: Log.=	1.146128
		2.392257
Answer=42″. 91	=	1.632589

Or thus; 5.75 days : Arith. Co.	Log.=	9.240332
17.625 : :	Log.=	1.246129
14 Seconds :	Log.=	1.146128
Answer=42″. 91	=	1.632589

2d. Find a fourth proportional to 9.485, 1.969 and 347.2.

98.45	:	Log.=1.993216
347.2	: :	Log.=2.540580
1.969	:	Log.=0.294246
		2.834826
Answer=6.944		=0.841610

3d. What number will have the same proportion to .8538 as .3275 has to .0131

.0131	:	Log.=—2.117271
.3275	: :	Log.=—1.515211
.8538	:	Log.=—1.931356
		—1.446567
Answer=21.35=		1.329296

4th. Required a third proportional number to 9.642 and 4.821

9.642	:	Log.=0.984167
4.821	: :	Log.=0.683137
4.821	:	Log.=0.683137
		1.366274
Answer=2.411		=0.382107

INVOLUTION.

To find any proposed power of a given number by Logarithms.

Rule. Multiply the Logarithm of the given number by the Index of the proposed power, and the

product will be the Logarithm, whose natural number is the power required.

When a negative Index is thus multiplied, its product is negative, but what was carried from the decimal part of the Logarithm must be affirmative; consequently the difference is the index of the product, which difference must be considered of the same kind with the greater, or that which was made the minuend.

EXAMPLES.

1. What is the second power of 3.874?

Log. of 3.874=0.588160
Index = 2

Power required=15.01 =1.176320

2. Required the third power of the number 2,768.

Log. of 2.768=0.442166
Index = 3

Answer=21.21 =1.326498

3. Required the second power of the number .2857.

Log. of .2857=—1.455910
Index = 2

Answer=.08162=—2.911820

4. Required the third power of the number .7916.

Log. of .7916=—1.898506
Index = 3

Answer=.4961 =—1.695518

EVOLUTION.

To extract any proposed Root of a given number by Logarithms.

RULE.

Find the Logarithm of the given number, and divide it by the Index of the proposed root; the quotient is a Logarithm, whose natural number is the root required.

When the index of the Logarithm to be divided, is negative, and does not exactly contain the divisor without some remainder, increase the index by such a number, as will make it exactly divisible by the index, carrying the units borrowed as so many tens to the left hand place of the decimal, and then divide as in whole numbers.

EXAMPLES.

1. Required the square root of 847.
Index 2)2.927883=Log. of 847.

1.463941=Quot.=Log.of29.103+=ans.

2. Required the cube root of 847.
Index 3)2.927883=Log. of the given number.

0.975961=Quot.=Log. of 9.462=ans. [nearly.

3. Required the square root of .093.
Index 2)—2.968483=Log. of .093.

—1.484241=Quot.=Log.of.304959=ans.

4. Required the cube root of 12345.
Index 3)4.091491=Log. of 12345.

1.363830=Quot.=Log. of 23.116.=Ans.

SECTION IV.

ELEMENTS OF

PLANE GEOMETRY.

DEFINITIONS.

See PLATE I.

1. GEOMETRY is that science wherein we consider the properties of magnitude.

2. A point is that which has no parts, being of itself indivisible; as *A*.

3. A line has length but no breadth; as *AB*. figures 1 and 2.

4. The extremities of a line are points, as the extremities of the line *AB* are the points *A* and *B*. figures 1 and 2.

5. A right line is the shortest that can be drawn between any two points, as the line *AB*. fig. 1. but if it be not the shortest, it is then called a curve line, as *AB*. fig. 2.

6. A superficies or surface is considered only as having length and breadth, without thickness, as *ABCD*. fig. 3.

7. The extremities of a superficies are lines.

8. The inclination of two lines meeting one another (provided they do not make one continued

line) or the opening between them, is called an angle. Thus in fig. 4. the inclination of the line *AB* to the line *BC* meeting each other in the point *B*, or the opening of the two lines *BA* and *BC*, is called an angle, as *ABC*.

Note, When an angle is expressed by three letters, the middle one is that at the angular point.

9. When the lines that form the angle are right ones, it is then called a right-lined angle, as *ABC*, fig. 4. If one of them be right and the other curved, it is called a mixed angle, as *B*. fig. 5. If both of them be curved, it is called a curved-lined or spherical angle, as *C*. fig. 6.

10. If a right line, *CD* (fig. 7.) fall upon another right line, *AB*, so as to incline to neither side, but make the angles *ADC*, *CDB* on each side equal to each other, then those angles are called right angles, and the line *CD* a perpendicular.

11. An obtuse angle is that which is wider or greater than a right one, as the angle *ADE*. fig. 7. and an acute angle is less than a right one, as *EDB*. fig. 7.

12. Acute and obtuse angles in general are called oblique angles.

13. If a right line *CB*. (fig. 8.) be fastened at the end *C*, and the other end *B*, be carried quite round, then the space comprehended is called a circle; and the curve line described by the point *B*, is called the circumference or the periphery of the circle; the fixed point *C*, is called its centre.

14. The describing line *CB*. (fig. 8.) is called the semidiameter or radius, so is any line from the centre to the circumference: whence all radii of the same or of equal circles are equal.

15. The diameter of a circle is a right line drawn thro' the centre, and terminating in opposite points of the circumference; and it divides the circle and circumference into two equal parts, called semicircles; and is double the radius, as *AB* or *DE*. fig. 8.

16. The circumference of every circle is supposed to be divided into 360 equal parts called degrees, and each degree into 60 equal parts called minutes, and each minute into 60 equal parts called seconds, and these into thirds, fourths, &c. these parts being greater or less as the radius is.

17. A chord is a right line drawn from one end of an arc or arch (that is, any part of the circumference of a circle) to the other; and is the measure of the arc. Thus the right line *HG*, is the measure of the arc *HBG*. fig. 8.

18. The segment of a circle is any part thereof, which is cut off by a chord: thus the space which is comprehended between the chord *HG* and the arc *HBG*, or that which is comprehended between the said chord *HG* and the arc *HDAEG* are called segments. Whence it is plain, fig. 8.

1. That any chord will divide the circle into two segments.

2. The less the chord is, the more unequal are the segments.

3. When the chord is greatest it becomes a diameter, and then the segments are equal; and each segment is a semicircle.

19. A sector of a circle is a part thereof less than a semicircle, which is contained between two radii and an arc: thus the space contained between the two radii *CH, CB*, and the arc *HB* is a sector. fig. 8.

20. The right sine of an arc, is a perpendicular line let fall from one end thereof, to a diameter drawn to the other end: thus *HL* is the right sine of the arc *HB*.

The sines on the same diameter increase till they come to the centre, and so become the radius; hence it is plain that the radius *CD* is the greatest possible sine, and thence is called the whole sine.

Since the whole sine *CD* (fig. 8.) must be perpendicular to the diameter (by def. 20.) therefore producing *DC* to *E*, the two diameters *AB* and *DE* cross one another at right angles, and thus the periphery is divided into four equal parts, as *BD*, *DA*, *AE*, and *EB*; (by def. 10.) and so *BD* becomes a quadrant or the fourth part of the periphery: therefore the radius *DC* is always the sine of a quadrant, or of the fourth part of the circle *BD*.

Sines are said to be of as many degrees as the arc contains parts of 360: so the radius being the sine of a quadrant becomes the sine of 90 degrees, or the fourth part of the circle, which is 360 degrees.

21. The versed sine of an arc is that part of the diameter that lies between the right sine and the circumference: thus *LB* is the versed sine of the arc *HB*. fig. 8.

22. The tangent of an arc is a right line touching the periphery, being perpendicular to the end of the diameter, and is terminated by a line drawn from the centre through the other end: thus *BK* is the tangent of the arc *HB*. fig. 8.

23. And the line which terminates the tangent, that is, *CK*, is called the secant of the arc *HB*. fig. 8.

24. What an arc wants of a quadrant is called the complement thereof: Thus *DH* is the complement of the arc *HB*. fig. 8.

25. And what an arc wants of a semicircle is called the supplement thereof: thus *AH* is the supplement of the are *HB*. fig. 8.

26. The sine, tangent, or secant of the complement of any arc, is called the co-sine, co-tangent, or co-secant of the arc itself: thus *FH* is the sine, *DI* the tangent, and *CI* the secant of the arc *DH*: or they are the co-sine, co-tangent, or co-secant of the arc *HB*. fig. 8.

27. The sine of the supplement of an arc, is the same with the sine of the arc itself; for drawing them according to def. 20, there results the self-same line; thus *HL* is the sine of the arc *HB*, or of its supplement *ADH*. fig. 8.

28. The measure of a right-lined angle, is the arc of a circle swept from the angular point, and

contained between the two lines that form the angle: thus the angle *HCB* (fig. 8.) is measured by the arc *HB*; and is said to contain so many degrees as the arc *HB* does; so if the arc *HB* is 60 degrees, the angle *HCB* is an angle of 60 degrees.

Hence angles are greater or less according as the arc described about the angular point, and terminated by the two sides, contains a greater or less number of degrees of the whole circle.

29. The sine, tangent, and secant of an arc, is also the sine, tangent, and secant of an angle whose measure the arc is: thus because the arc *HB* is the measure of the angle *HCB*, and since *HL* is the sine, *BK* the tangent, and *CK* the secant, *BL* the versed sine, *HF* the co-sine, *DI* the co-tangent, and *CI* the co-secant, &c. of the arc *BH*; then *HL* is called the sine, *BK* the tangent, *CK* the secant, &c. of the angle *HCB*, whose measure is the arc *HB*. fig. 8.

30. Parallel lines are such as are equi-distant from each other, as *AB*, *CD*. fig. 9.

31. A figure if a space bounded by a line or lines. If the lines be right it is called a rectilineal figure, if curved it is called a curvilineal figure; but if they be partly right and partly curved lines, it is called a mixed figure.

32. The most simple rectilineal figure is a triangle, being composed of three right lines, and is considered in a double capacity; 1st, with respect to its sides; and 2d, to its angles.

33. In respect to its sides it is either equilateral, having the three sides equal, as *A*. fig. 10.

34. Or isosceles, having two equal sides, as *B*. fig. 11.

35. Or scalene, having the three sides unequal, as *C*. fig. 12.

36. In respect to its angles, it is either right-angled, having one right angle, as *D*. fig. 13.

37. Or obtuse angled, having one obtuse angle, as *E*. fig. 14.

38. Or acute angled, having all the angles acute, as *F*. fig. 15.

39. Acute and obtuse angled triangles are in general called oblique angled triangles, in all which any side may be called the base, and the other two the sides.

40. The perpendicular height of a triangle is a line drawn from the vertex to the base perpendicularly: thus if the triangle *ABC*, be proposed, and *BC* be made its base, then if from the vertex *A* the perpendicular *AD* be drawn to *BC*, the line *AD* will be the height of the triangle *ABC*, standing on *BC* as its base. Fig. 16.

Hence all triangles between the same parallels have the same height, since all the perpendiculars are equal from the nature of parallels.

41. Any figure of four sides is called a quadrilateral figure.

42. Quadrilateral figures, whose opposite sides are parallel, are called parallelograms: thus

ABCD is a parallelogram. Fig. 3. 17, and *AB*. fig. 18 and 19.

43. A parallelogram whose sides are all equal and angles right, is called a square, as *ABCD*. fig. 17.

44. A parallelogram whose opposite sides are equal and angles right, is called a rectangle, or an oblong, as *ABCD*. fig. 3.

45. A rhombus is a parallelogram of equal sides, and has its angles oblique, as *A*. fig. 18. and is an inclined square.

46. A rhomboides is a parallelogram whose opposite sides are equal and angles oblique; as *B*. fig. 19. and may be conceived as an inclined rectangle.

47. Any quadrilateral figure that is not a parallelogram, is called a trapezium. Plate 7. fig. 3.

48. Figures which consist of more than four sides are called polygons; if the sides are all equal to each other, they are called regular polygons. They sometimes are named from the number of their sides, as a five-sided figure is called a pentagon, one of six sides a hexagon, &c. but if their sides are not equal to each other, then they are called irregular polygons, as an irregular pentagon, hexagon, &c.

49. Four quantities are said to be in proportion when the product of the extremes is equal to that of the means: thus if *A* multiplied by *D*, be equal to *B* multiplied by *C*, then *A* is said to be to *B* as *C* is to *D*.

POSTULATES OR PETITIONS.

1. That a right line may be drawn from any one given point to another.

2. That a right line may be produced or continued at pleasure.

3. That from any centre and with any radius, the circumference of a circle may be described.

4. It is also required that the equality of lines and angles to others given, be granted as possible: that it is possible for one right line to be perpendicular to another, at a given point or distance; and that every magnitude has its half, third, fourth, &c. part.

Note, Though these postulates are not always quoted, the reader will easily perceive where, and in what sense they are to be understood.

AXIOMS *or self-evident* TRUTHS.

1. Things that are equal to one and the same thing, are equal to each other.

2. Every whole is greater than its part.

3. Every whole is equal to all its parts taken together.

4. If to equal things, equal things be added, the whole will be equal.

5. If from equal things, equal things be deducted, the remainders will be equal.

6. If to or from unequal things, equal things be added or taken, the sums or remainders will be unequal.

7. All right angles are equal to one another.

8. If two right lines not parallel, be produced towards their nearest distance, they will intersect each other.

9. Things which mutually agree with each other, are equal.

NOTES.

A theorem is a proposition, wherein something is proposed to be demonstrated.

A problem is a proposition, wherein something is to be done or effected.

A lemma is sôme demonstration, previous and necessary, to render what follows the more easy.

A corollary is a consequent truth, deduced from a foregoing demonstration.

A scholium, is a remark or observation made upon something going before.

GEOMETRICAL THEOREMS.

THEOREM I.

Pl. 1, *fig.* 20.

IF a right line falls on another, as AB, or EB, does on CD, it either makes with it two right angles, or two angles equal to two right angles.

1. If AB be perpendicular to CD, then (by def. 10.) the angles CBA, and ABD, will be each a right angle.

2. But if EB fall slantwise on CD, then are the angles $DBE+EBC=DBE+EBA$ $(=DBA)+ABC$, or two right angles. *Q. E. D.*

Corollary 1. Whence if any numbers of right lines were drawn from one point, on the same side of a right line; all the angles made by these lines will be equal to two right lines.

2. And all the angles which can be made about a point, will be equal to four right angles.

THEO. II.

Pl. 1. *fig.* 21.

If one right line cross another, (as AC does BD) the opposite angles made by those lines, will be equal to each other: that is, AEB to CED, and BEC to AED.

By theorem 1. $BEC + CED = 2$ right angles.
and $CED + DEA = 2$ right angles.

Therefore (by axiom 1.) $BEC+CED=CED+$

DEA: take *CED* from both, and there remains $BEC = DEA$. (by axiom 5.) *Q. E. D.*

After the same manner $CED + AED = 2$ right angles; and $AED + AEB =$ two right angles; wherefore taking *AED* from both, there remains $CED = AEB$. *Q. E. D.*

THEO. III.

PL. 1. *fig.* 22.

If a right line cross two parallels, as GH does AB and CD, then,

1. *Their external angles are equal to each other, that is,* $GEB = CFH$.

2. *The alternate angles will be equal, that is,* $AEF = EFD$ *and* $BEF = CFE$.

3. *The external angle will be equal to the internal and opposite one on the same side, that is,* $GEB = EFD$ *and* $AEG = CFE$.

4. *And the sum of the internal angles on the same side, are equal to two right angles; that is,* $BEF + DFE$ *are equal to two right angles, and* $AEF + CFE$ *are equal to two right angles.*

1. Since *AB* is parallel to *CD*, they may be considered as one broad line, crossed by another line, as *GH*; (then by the last theo.) $GEB = CFH$, and $AEG = HFD$.

2. Also $GEB = AEF$, and $CFH = EFD$; but $GEB = CFH$ (by part 1. of this theo.) therefore $AEF = EFD$. The same way we prove $FEB = EFC$.

3. $AEF = EFD$; (by the last part of this theo.) but $AEF = GEB$ (by theo. 2.) Therefore $GEB = EFD$. The same way we prove $AEG = CFE$.

4. For since $GEB = EFD$, to both add FEB, then (by axiom 4.) $GEB + FEB = EFD + FEB$, but $GEB + FEB$, are equal to two right angles (by theo. 1.) Therefore $EFD + FEB$ are equal to two right angles: after the same manner we prove that $AEF + CFE$ are equal to two right angles. *Q. E. D.*

THEO. IV.

Pl. 1. *fig.* 23.

In any triangle ABC, one of its legs, as BC, being produced towards D, it will make the external angle ACD equal to the two internal opposite angles taken together. Viz. to B and A.

Through C, let CE be drawn parallel to AB; then since BD cuts the two parallel lines BA, CE; the angle $ECD = B$, (by part 3. of the last theo.) and again, since AC cuts the same parallels, the angle $ACE = A$ (by part. 2. of the last.) Therefore $ECD + ACE = ACD = B + A$. *Q. E. D.*

THEO. V.

Pl. 1. *fig.* 23.

In any triangle ABC, all the three angles, taken together, are equal to two right angles, viz. $A + B + ACB = 2$ *right angles.*

Produce CB to any distance, as D, then (by the last) $ACD = B + A$; to both add ACB; then $ACD + ACB = A + B + ACB$; but $ACD + ACB = 2$ right angles (by theo. 1.); therefore the three angles $A + B + ACB = 2$ right angles. *Q. E. D.*

Cor. 1. Hence if one angle of a triangle be known, the sum of the other two is also known: for since the three angles of every triangle contain two right ones, or 180 degrees, therefore 180

—the given angle will be equal to the sum of the other two; or 180—the sum of two given angles, gives the other one.

Cor. 2. In every right-angled triangle, the two acute angles are =90 degrees, or to one right angle: therefore 90 — one acute angle, gives the other.

THEO. VI.

Pl. 1. *fig.* 24.

If in any two triangles, ABC, DEF, there be two sides, AB, AC in the one, severally equal to DE, DF in the other, and the angle A contained between the two sides in the one, equal to D in the other; then the remaining angles of the one, will be severally equal to those of the other, viz. B = E and C = F: and the base of the one BC, will be equal to EF, that of the other.

If the triangle ABC be supposed to be laid on the triangle DEF, so as to make the points A and B coincide with D and E, which they will do, because $AB = DE$ (by the hypothesis); and since the angle $A = D$, the line AC will fall along DF, and inasmuch as they are supposed equal, C will fall in F; seeing therefore the three points of one coincide with those of the other triangle, they are manifestly equal to each other; therefore the angle $B = E$ and $C = F$, and $BC = EF$. Q. E. D.

LEMMA.

Pl. 1. *fig.* 11.

If two sides of a triangle a b c be equal to each other, that is, ac = cb, the angles which are opposite to those equal sides, will also be equal to each other; viz. a = b.

For let the triangle $a\ b\ c$ be divided into two

triangles $a\ c\ d$, $d\ c\ b$, by making the angle $a\ c\ d = d\ c\ b$ (by postulate 4.) then because $a\ c = b\ c$, and cd common, (by the last) the triangle $a\ d\ c = d\ c\ b$; and therefore the angle $a = b$. *Q. E. D.*

Cor. Hence if from any point in a perpendicular which bisects a given line, there be drawn right lines to the extremeties of the given one, they with it will form an isosceles triangle.

THEO. VII.

Pl. 1. *fig.* 25.

The angle BCD at the centre of a circle ABED, is double the angle BAD at the circumference, standing upon the same arc BED.

Through the point A, and the centre C, draw the line ACE: then the angle $ECD = CAD, + CDA$; (by theo. 4.) but since $AC = CD$ being radii of the same circle, it is plain (by the preceding lemma) that the angles subtended by them will be also equal, and that their sum is double to either of them, that is, $DAC + ADC$ is double to CAD, and therefore ECD is double to CAD; after the same manner BCE is double to CAB, wherefore, $BCE + ECD$, or BCD is double to $BAC + CAD$ or to BAD. Q. E. D.

Cor. 1. Hence an angle at the circumference is measured by half the arc it subtends or stands on.

Fig. 26.

Cor. 2. Hence all angles at the circumference of a circle which stands on the same chord as AB, are equal to each other, for they are all measured by half the arc they stand on, *viz.* by half the arc AB.

Fig. 26.

Cor. 3. Hence an angle in a segment greater than a semicircle is less than a right angle; thus *ADB* is measured by half the arc *AB*, but as the arc *AB* is less than a semicircle, therefore half the arc *AB*, or the angle *ADB* is less than half a semicircle, and consequently less than a right angle.

Fig. 27.

Cor. 4. An angle in a segment less than a semicircle, is greater than a right angle, for since the arc *AEC* is greater than a semicircle, its half, which is the measure of the angle *ABC*, must be greater than half a semicircle, that is, greater than a right angle.

Fig. 28.

Cor. 5. An angle in a semicircle is a right angle, for the measure of the angle *ABD*, is half of a semicircle *AED*, and therefore a right angle.

THEO. VIII.

Pl. 1. *fig.* 29.

If from the centre C of a circle ABE, there be let fall the perpendicular CD on the chord AB, it will bisect it in the point D.

Let the lines *AC* and *CB* be drawn from the centre to the extremities of the chord, then since *CA*=*CB*, the angles *CAB*=*CBA* (by the lemma.) But the triangles *ADC*, *BDC* are right angled ones, since the line *CD* is a perpendicular; and so the angle *ACD*=*DCB*; (by cor. 2. theo. 5.) then have we *AC*, *CD*, and the angle *ACD* in one triangle; severally equal to *CB*, *CD*, and the angle

BCD in the other: therefore (by theo. 6.) *A*= *DB*. *Q. E. D.*

Cor. Hence it follows, that any line bisecting a chord at right angles, is a diameter; for a line drawn from the centre perpendicular to a chord, bisects that chord at right angles; therefore, conversely, a line bisecting a chord at right angles must pass through the centre, and consequently be a diameter.

THEO. IX.

Pl. 1. *fig.* 29.

If from the centre of a circle ABE there be drawn a perpendicular CD on the chord AB, and produced till it meets the circle in F, that line CF, will bisect the arc AB in the point F.

Let the lines *AF* and *BF* be drawn, then in the triangles *ADF*, *BDF*; *AD*=*BD* (by the last;) *DF* is common, and the angle *ADF*=*BDF* being both right, for *CD* or *DF* is a perpendicular. Therefore (by theo. 6.) *AF* = *FB*; but in the same circle, equal lines are chords of equal arcs, since they measure them (by def. 19.): whence the arc *AF*=*FB*, and so *AFB* is bisected in *F*, by the line *CF*.

Cor. Hence the sine of an arc is half the chord of twice that arc. For *AD* is the sine of the arc *AF*, (by def. 22.) *AF* is half the arc, and *AD* half the chord *AB* (by theo. 8.) therefore the corollary is plain.

THEO. X.

Pl. 1. *fig.* 30.

In any triangle ABD, the half of each side is the sine of the opposite angle.

Let the circle *ADB* be drawn through the points *A*, *B*, *D*; then the angle *DAB* is measured by half the arc *BKD*, (by cor 1 theo. 7.) *viz.* the chord of *BK* is the measure of the angle *BAD*; therefore (by cor. to the last) *BE* the half of *BD* is the sine of *BAD*: the same way may be proved that half of *AD* is the sine of *ABD*, and the half of *AB* the sine of *ADB*. *Q. E. D.*

THEO. XI.

Pl. 1. fig. 22.

If a right line GH cut two other right lines AB, CD, so as to make the alternate angles AEF, EFD equal to each other, then the lines AB and CD will be parallel.

If it be denied that *AB* is parallel to *CD*, let *IK* be parallel to it; then *IEF*=(*EFD*)=*AEF* (by part 2. theo. 3.) a greater to a less, which is absurd, whence *IK* is not parallel; and the like we can prove of all other lines but *AB*; therefore *AB* is parallel to *CD*. *Q. E. D.*

THEO. XII.

Pl. 1. fig. 3.

If two equal and parallel lines AB, CD, be joined by two other lines AD, BC, those shall be also equal and parallel.

Let the diameter or diagonal *BD* be drawn, and we will have the triangles *ABD*, *CBD*: whereof *AB* in one is= to *CD* in the other, *BD* common to both, and the angle *ABD*=*CDB* (by part 2. theo. 3.;) therefore (by theo. 6.) *AD*=*CB*, and the angle *CBD* =*ADB*, and thence the lines *AD* and *BC* are parallel, by the preceding theorem.

Cor. 1. Hence the quadrilateral figure *ABCD* is a parallelogram, and the diagonal *BD* bisects the

same, inasmuch as the triangle $ABD = BCD$, as now proved.

Cor. 2. Hence also the triangle ABD on the same base AB, and between the same parallels with the parallelogram $ABCD$, is half the parallelogram.

Cor. 3. It is hence also plain, that the opposite sides of a parallelogram are equal; for it has been proved that $ABCD$ being a parallelogram, AB will be $= CD$ and $AD = BC$.

THEO. XIII.

Pl. 1. fig. 31.

All parallelograms on the same or equal bases and between the same parallels, are equal to one another, that is, if $BD = GH$, and the lines BH and AF parallel, then the parallelogram $ABDC = BDFE = EFHG$.

For $AC = BD = EF$ (by cor. the last;) to both add CE then $AE = CF$. In the triangles ABE, CDF; $AB = CD$ and $AE = CF$ and the angle $BAE = DCF$ (by part 3. theo. 3.;) therefore the triangle $ABE = CDF$, (by theo. 6.) let the triangle CKE be taken from both, and we will have the trapezium $ABKC = KDFE$; to each of these add the triangle BKD, then the parallelogram $ABCD = BDEF$; in like manner we may prove the parallelogram $EFGH = BDEF$. Wherefore $ABDC = BDEF = EFHG$. Q. E. D.

Cor. Hence it is plain that triangles on the same or equal bases, and between the same parallels, are equal, seeing (by cor. 2. theo. 12.) they are the halves of their respective parallelogram.

THEO. XIV.

Pl. 1. *fig.* 32.

In every right-angled triangle, ABC, the square of the hypothenuse or longest side, BC, or BCMH, is equal to the sum of the squares made on the other two sides AB and AC, that is, ABDE and ACGF.

Through *A* draw *AKL* perpendicular to the hypothenuse *BC*, join *AH*, *AM*, *DC* and *BG*; in the triangles, *BDC*, *ABH*, *BD* = *BA*, being sides of the same square, and also *BC* = *BH*, and the included angles *DBC* = *ABH*, (for *DBA* = *CBH* being both right, to both add *ABC*, then *DBC* = *ABH*) therefore the triangle *DBC* = *ABH* (by theo. 6.) but the triangle *DBC* is half of the square *ABDE* (by cor. 2 theo. 12.) and the triangle *ABH* is half the parallelogram *BKLH*. The same way it may be proved, that the square *ACGF*, is equal to the parallelogram *KCLM*. So *ABDE*+*ACGF* the sum of the squares=*BKLH* + *KCML*, the sum of the two parallelograms or square *BCMH*; therefore the sum of the squares on *AB* and *AC* is equal to the square on *BC*. *Q. E. D.*

Cor. 1. Hence the hypothenuse of a right-angled triangle may be found by having the sides; thus, the square root of the sum of the squares of the base and perpendicular, will be the hypothenuse.

Cor. 2. Having the hypothenuse and one side given to find the other; the square root of the difference of the squares of the hypothenuse and given side, will be the required side.

THEO. XV.

Pl. 1. *fig.* 33.

In all circles the chord of 60 degrees is always equal in length to the radius.

Thus in the circle AEBD, if the arc AEB be an arc of 60 *degrees, and the chord AB be drawn: then AB = CB = AC.*

In the triangle *ABC*, the angle *ACB* is 60 degrees, being measured by the arc *AEB*; therefore the sum of the other two angles is 120 degrees (by Cor. 1. theo. 5.) but since *AC*=*CB*, the angle *CAB*=*CBA* (by lemma preceding theo. 7.) consequently each of them will be 60, the half of 120 degrees, and the three angles will be equal to one another, as well as the three sides: wherefore *AB* =*BC*=*AC*. *Q. E. D.*

Cor. Hence the radius, from whence the lines on any scale are formed, is the chord of 60 degrees on the line of chords.

THEO. XVI.

Pl. 1. *fig.* 34.

If in two triangles ABC, abc, all the angles of one be each respectively equal to all the angles of the other, that is, A = a, B = b, C = c: then the sides opposite to the equal angles will be proportional, viz.

AB : ab : : AC : ac
AB : ab : : BC : bc
and AC : ac : : BC : bc

For the triangles being inscribed in two circles, it is plain since the angle *A*= *a*, the arc *BDC*= *b d c*, and consequently the chord *BC* is to *b c*, as the radius of the circle *ABC* is to the radius of the circle *a b c*; (for the greater the radius is, the greater is the circle described by that radius; and consequently the greater any particular arc of that circle is, so the chord, sine, tangent, *&c.* of that arc will be also greater. Therefore, in general, the chord, sine, tangent, *&c.* of any arc is proportional to the radius of the circle;) the same way the chord

AB is to the chord *ab*, in the same proportion. So $AB : ab :: BC : bc$; the same way the rest may be proved to be proportional.

THEO. XVII.

PL. 1. *fig.* 35.

If from a point A without a circle DBCE there be drawn two lines ADE, ABC, each of them cutting the circle in two points; the product of one whole line into its external part, viz. AC into AB, will be equal to that of the other line into its external part, viz. AE into AD.

Let the lines *DC, BE*, be drawn in the two triangles *ABE, ADC;* the angle $AEB = ACD$ (by cor. 2. theo. 7.) the angle *A* is common, and (by cor. 1. theo. 5.) the angle $ADC = ABE$; therefore the triangles *ABE, ADC*, are mutually equiangular, and consequently (by the last) $AC : AE :: AD : AB$; wherefore *AC* multiplied by *AB*, will be equal to *AE* multiplied by *AD*. *Q. E. D.*

THEO. XVIII.

PL. 2. *fig.* 1.

Triangles ABC, BCD, and parallelograms ABCF and BDEC, having the same altitude, have the same proportion between themselves as their bases BA and BD.

Let any aliquot part of *AB* be taken, which will also measure *BD:* suppose that to be *Ag*, which will be contained twice in *AB*, and three times in *BD*, the parts *Ag, gB, Bh, hi*, and *i D* being all equal, and let the lines *gC, hC*, and *i C*, be drawn: then (by cor. to theo. 13.) all the small triangles *AgC, gCB, BCh, &c.* will be equal to each other; and will be as many as the parts into which their bases were divided; therefore it will be as the sum of the parts in one base, is to the

sum of those in the other, so will be the sum of the small triangles in the first, to the sum of the small triangles in the second triangle; that is, *AB* : *BD* : : *ABC* : *BDC*.

Whence also the parallelograms *ABCF* and *BDEC*, being (by cor. 2. theo. 12.) the doubles of the triangles, are likewise as their bases. *Q. E. D.*

Note. Wherever there are several quantities connected with the sign (: :) the conclusion is always drawn from the first two and last two proportionals,

THEO. XIX.

Pl. 2. *fig.* 2.

Triangles ABC, DEF, standing upon equal bases AB and DE, are to each other as their altitudes CG and FH.

Let *BI* be perpendicular to *AB* and equal to *CG*, in which let *KB* = *FH*, and let *AI* and *AK* be drawn.

The triangle *AIB*=*ACB* (by cor. to theo. 13.) and *AKB*=*DEF*; but (by theo. 18.) *BI* : *BK* : : *ABI* : *ABK*. That is, *CG* : *FH* : : *ABC* : *DEF*. *Q. E. D.*

THEO. XX.

Pl. 2. *fig.* 3.

If a right line BE be drawn parallel to one side of a triangle ACD, it will cut the two other sides proportionally, viz. AB : BC : : AE : ED.

Draw *CE* and *BD*; the triangles *BEC* and *EBD* being on the same base *BE* and under the same parallel *CD*, will be equal (by cor. to theo. 13.)

therefore (by theo. 18) $AB : BC :: (BEA : BEC$ or $BEA : BED) :: AE : ED$. *Q. E. D.*

Cor. 1. Hence also $AC : AB :: AD : AE$: For $AC : AB :: (AEC : AEB :: ABD : AEB) :: AD : AE$.

Cor. 2. It also appears that a right line, which divides two sides of a triangle proportionally, must be parallel to the remaining side.

Cor. 3. Hence also, theo. 16. is manifest; since the sides of the triangles ABE, ACD, being equiangular, are proportional.

THEO. XXI.

Pl. 2. fig. 4.

If two triangles ABC, ADE, have an angle BAC, in the one, equal to an angle DAE, in the other, and the sides about the equal angles, proportional; that is, $AB : AD :: AC : AE$; then the triangles will be mutually equiangular.

In AB take $Ad = AD$, and let $d\,e$ be parallel to BC, meeting AC in e.

Because (by the first cor. to the foregoing theo.) $AB : Ad$ (or AD) $:: AC : Ae$, and (by the hypothesis, or what is given in the theorem) $AB : AD : AC : AE$; therefore $Ae = AE$ seeing AC bears the same proportion to each; and (by theo. 6.) the triangle $Adc = ADE$, therefore the angle $Ade = D$ and $Aed = E$, but since ed and BC are parallel (by part 3. theo. 3) $Ade = B$, and $Aed = C$, therefore $B = D$ and $C = E$. *Q. E. D.*

THEO. XXII.

Pl. 2. fig. 5.

Equiangular triangles ABC, DEF, are to one another in

a duplicate proportion of their homologous or like sides; or as the squares AK, and DM of their homologous sides.

Let the perpendiculars *CG* and *FH* be drawn as well as the diagonals *BI* and *EL*.

The perpendiculars make the triangles *ACG* and *DFH* equiangular, and therefore similar (by theo. 16.) for because the angle *CAG*=*FDH*, and the right angle *AGC*=*DHF*, the remaining angle *ACG*=*DFH*, (by cor. 2. theo. 5.)

Therefore *GC* : *FH* : : (*AC* : *DF* : :)*AB* : *DE*, or which is the same thing, *GC* : *AB* : : *FH* : *DE* for *FH* multiplied by *AB* = *AB* multiplied by *FH*.

By theo. 19. *ABC* : *ABI* : : (*CG* : *AI* or *AB* as before : : *FH DE* or *DL* : :) *DFE* : *DLE*, therefore *ABC* : *ABI* : : *DFE* : *DLE*, or *ABC*: *AK* : : *DFE* : *DM*, for *AK* is double the triangle *ABI*, and *DM* double the triangle *DEL*, by cor. 2. theo. 12. *Q. E. D.*

THEO. XXIII.

PL. 2. fig. 6.

Like polygons ABCDE, a b c d e, are in a duplicate proportion to that of the sides AB, a b, which are between the equal angles A and B and a and b, or as the squares of the sides AB, ab.

Draw *AD*, *AC*, *ad*, *ac*.

By the hypothesis *AB* : *ab* : : *BC* : *bc*; and thereby also the angle *B* = *b*; therefore (by theo. 21.) *BAC* = *b a c*; and *ACB* = *a c b* : in like manner *EAD*=*e a d*, and *EDA*=*e d a*. If therefore from the equal angles *A*, and *a*, we take the equal ones

EAD +*BAC*=*e a d*,+ *b a c* the remaining angle *DAC*= *d a c*, and if from the equal angles *D* and *d*, *EDA*=*e d a*, be taken, we shall have *ADC*=*a d c*: and in like manner if from *C* and *c* be taken *BCA*, = *b c a*, we shall have *ACD* =*a c d*; and so the respective angles in every triangle, will be equal to those in the other.

By theo. 22. *ABC* : *a b c* : : the square of *AC* to the square of *ac*, and also *ADC* : *adc* : : the square of *AC*, to the square of *a c* ; therefore from equality of proportions *ABC* : *abc* : : *ADC* : *a d c* ; in like manner we may shew that *ADC* : *a d c* : *EAD* : *e a d* : Therefore it will be as one antecedent is to one consequent, so are all the antecedents to all the consequents. That is, *ABC* is to *a b c* as the sum of the three triangles in the first polygon, is to the sum of those in the last. Or *ABC* will be to *a b c*, as polygon to polygon.

The proportion of *ABC* to *a b c* (by the foregoing theo.) is as the square of *AB* is to the square of *a b*, but the proportion of polygon to polygon, is as *ABC* to *a b c*, as now shown: therefore the proportion of polygon to polygon is as the square of *AB* to the square of *ab*.

THEO. XXIV.

PL. 1. *fig.* 8.

Let DHB be a quadrant of a circle described by the radius CB; HB an arc of it, and DH its complement; HL or FC the sine, FH or CL its co-sine, BK its tangent, DI its co-tangent; CK its secant, and CI its co-secant. Fig. 8.

1. The co-sine of an arc is to the sine, as the radius is to the tangent.

2. The radius is to the tangent of an arc, as the co-sine of it is to the sine.

3. The sine of an arc is to its co-sine, as the radius to its co-tangent;

4. Or the radius is to the co-tangent of an arc, as its sine to its co-sine.

5. The co-tangent of an arc is to the radius, as the radius to the tangent.

6. The co-sine of an arc is to the radius, as the radius is to the secant.

7. The sine of an arc is to the radius, as the tangent is to the secant.

The triangles *CLH* and *CBK*, being similar, (by theo. 16.)

1. $CL : LH : : CB : BK.$

2. Or, $CB : BK : : CL : LH.$

The triangles *CFH* and *CDI*, being similar.

3. CF (or LH) $: FH : : CD : DI.$

4. $CD : DI : : CF$ (or LH) $: FH.$

The triangles *CDI* and *CBK* are similar: for the angle $CID = KCB$, being alternate ones (by part 2. theo. 3.) the lines *CB* and *DI* being parallel: the angle $CDI = CBK$ being both right, and consequently the angle $DCI = CKB$, wherefore,

5. $DI : CD : : CB : BK.$

And again, making use of the similar triangle CLH and CBK.

6. $CL : CB :: CH : CK$.

7. $HL : CH : BK : CK$.

GEOMETRICAL PROBLEMS.

PROB. I.

Pl. 2. *fig.* 7.

To make a triangle of three given right lines BO, LB, LO, of which any two must be greater than the third.

Lay BL from B to L; from B with the line BO, describe an arc, and from L with LO describe another arc; from O, the intersecting point of those arcs, draw BO and OL, and BOL is the triangle required.

This is manifest from the construction.

PROB. II.

Pl. 2. *fig.* 8.

At a point B in a given right line BC, to make an angle equal to a given angle A.

Draw any right line ED to form a triangle, as EAD, take $BF=AD$, and upon BF make the triangle BFG, whose side $BG=AE$, and $GF=ED$ (by the last) then also the angle $B = A$; if we suppose one triangle be laid on the other, the sides

will mutually agree with each other, and therefore be equal; for if we consider these two triangles to be made of the same three given lines, they are manifestly one and the same triangle.

Otherwise,

Upon the centres *A* and *B*, at any distance, let two arcs, *DE*, *FG*, be described; make the arc *FG*=*DE*, and through *B* and *G* draw the line *BG*, and it is done.

For since the chords *ED*, *GF*, are equal, the angles *A* and *B* are also equal, as before (by def. 17.)

PROB. III.

Pl. 2. *fig.* 9.

To bisect or divide into two equal parts, any given right-lined angle, BAC.

In the lines *AB* and *AC*, from the point *A* set off equal distances *AE*,=*AD*, then, with any distance more than the half of *DE*, describe two arcs to cut each other in some point *F*; and the right-line *AF*, joining the points *A* and *F*, will bisect the given angle *BAC*.

For if *DF* and *FE* be drawn, the triangles *ADF*, *AEF*, are equilateral to each other, *viz.* *AD*=*AE*, *DF*=*FE*, and *AF* common, wherefore *DAF*=*EAF*, as before.

PROB. IV.

Pl. 2. *fig.* 10.

To bisect a right-line. AB.

With any distance, more than half the line, from

A and *B*, describe two circles *CFD*, *CGD*, cutting each other in the points *C* and *D*; draw *CD* intersecting *AB* in *E*, then $AE=EB$.

For, if *AC*, *AD*, *BC*, *BD*, be drawn, the triangles *ACD*, *BCD*, will be mutually equilateral, and consequently the angle $ACE=BCE$: therefore the triangle *ACE*, *BCE*, having $AC=BC$, *CE* common, and the angle $ACE=BCE$; (by theo. 6.) the base $AE=$ the base *BE*.

Cor. Hence it is manifest, that *CD* not only bisects *AB*, but is perpendicular to it, (by def. 11.)

PROB. V.

Pl. 2. *fig.* 11.

On a given point A, in a right line EF, to erect a perpendicular.

From the point *A* lay off on each side, the equal distances, *AC*, *AD*; and from *C* and *D*, as centres, with any interval greater than *AC* or *AD*, describe two arcs intersecting each other in *B*; from *A* to *B* draw the line *AB*, and it will be the perpendicular required.

For, let *CB*, and *BD* be drawn; then the triangles *CAB*, *DAB*, will be mutually equilateral and equiangular, so $CAB=DAB$, a right angle, (by def. 10.)

PROB. VI.

Pl. 2. *fig.* 12.

To raise a perpendicular on the end B of a right line AB.

From any point *D* not in the line *AB*, with the distance from *D* to *B*, let a circle be described cut-

ting AB in E; draw from E through D the right line EDC, cutting the periphery in C, and join CB; and that is the perpendicular required.

EBC being a semicircle, the angle EBC will be a right angle (by cor. 5. theo. 7.)

PROB. VII.

Pl. 2. *fig.* 13.

From a given point A, to let fall a perpendicular upon a given right line BC.

From any point D, in the given line, take the distance to the given point A, and with it describe a circle AGE, make $GE=AG$, join the points A and E, by the line AFE, and AF will be the perpendicular required.

Let DA, DE, be drawn; the angle $ADF=FDE$, $DA=DE$, being radii of the same circle, and DF common; therefore (by theo. 6.) the angle $DFA=DFE$, and FA a perpendicular. (By def. 10.)

PROB. VIII.

Pl. 2. *fig.* 14.

Through a given point A, to draw a right line AB, parallel to a given right line CD.

From the point A, to any point F, in the line CD, draw the line AF; with the interval FA, and one foot of the compasses in F, describe the arc AE, and with the like interval and one foot in A, describe the arc BF, making $BF=AE$; through A and B draw the line AB, and it will be parallel to CD.

By prob. 2. The angle $BAF=AFE$, and by theo. 11. BA and CD are parallel.

PROB. IX.

Pl. 1. *fig.* 17.

Upon a given line AB to describe a square ABCD.

Make BC perpendicular and equal to AB; and from A and C, with the line AB, or BC, let two arcs be described, cutting each other in D; from whence to A and C, let the lines AD, DC be drawn; so is $ABCD$ the square required.

For all the sides are equal by construction; therefore the triangles ADC and BAC, are mutually equilateral and equiangular, and $ABCD$ is an equilateral parallelogram, whose angles are right. For B being right, D is also right, and DAC, DCA, BAC, ACB, each half a right angle, (by lemma preceding theo. 7. and cor. 2. theo. 5.) whence DAB and BCD will each be a right angle, and (by def. 44.) $ABCD$ is a square.

SCHOLIUM.

By the same method a rectangle or oblong, may be described, the sides thereof being given.

PROB. X.

Pl. 2. *fig.* 15.

To divide a given right line AB, into any proposed number of equal parts.

Draw the indefinite right line AP, making any angle with AB, also draw BQ parallel to AP, in

each of which, let there be taken as many equal parts *AM, MN, &c. Bo, on, &c.* as you would have *AB* divided into; then draw *Mm, Nn, &c.* intersecting *AB* in *E, F, &c.* and it is done.

For *MN* and *mn* being equal and parallel, *FN* will be parallel to *EM;* and in the same manner, *GO* to *FN* (by theo. 12.) therefore *AM, MN, NO*, being all equal by construction, it is plain (from theo. 10.) that *AE, EF, FG, &c.* will likewise be equal.

PROB. XI.

PL. 2. fig. 16.

To find a third proportional to two given right lines, A and B.

Draw two indefinite blank lines *CE, CD*, anywise to make any angle. Lay the line *A*, from *C* to *F;* and the line *B*, from *C*, to *G;* and draw the line *FG;* lay again the line *A*, from *C* to *H;* and through *H*, draw *HI* parallel to *FG* (by prob. 8.) so is *CI* the third proportional required.

For by cor. 1. theo. 20, $CG : CH :: CF : CI$.

Or, $B : A :: A : CI$.

PROB. XII.

PL. 2. fig. 17.

Three right lines A, B, C, given to find a fourth proportional.

Having made an angle *DEF* anywise, by two indefinite blank right lines, *ED, EF*, as before; lay the line *A*; from *E* to *G;* the line *B*, from *E* to *I;* and draw the line *IG;* lay the line *C*, from *E* to

H, and (by prob. 8.) draw *HK* parallel thereto, so will *EK* be the fourth proportional required.

For, by cor. 1. theo. 20. *EG* : *EI* : : *EH* : *EK*.

Or, *A* : *B* : : *C* : *EK*.

PROB. XIII.

Pl. 3. *fig.* 1.

Two right lines, A and B, given to find a mean proportional.

Draw an indefinite blank line, as *AF*, on which lay the line *A*, from *A* to *B*, and the line *B*, from *B* to *C*, on the point *B*, which is the joining point of the lines *A* and *B*; erect a perpendicular *BD* (by prob. 5.) bisect *AC* in *E* (by prob. 4.) and describe the semicircle *ADC*; and from the point *D*, where the periphery cuts the perpendicular *BD*, draw the line *BD*, and that will be the mean proportional required.

For if the lines *AD*, *DC*, be drawn, the angle *ADC* is a right angle (by cor. 5. theo. 7.) being an angle in a semicircle.

The angles *ABD*, *DBC*, are right ones (by def. 10.) the line *BD* being a perpendicular; wherefore the triangles *ABD*, *DBC*, are similar: thus the angle *ABD*=*DBC*, being both right, the angle *DAC* is the complement of *BDA* to a right angle (by cor. 2. theo. 5.) and is therefore equal to *BDC*, the angle *ADC* being a right angle as before; consequently (by cor. 1. theo. 5.) the angle *ADB*=*DCB*, wherefore (by theo. 16.)

AB : *BD* : : *BD* : *BC*.
Or, *A* : *BD* : : *BD* : *B*.

PROB. XIV.

Pl. 3. *fig.* 2.

To divide a right line AB, in the point E, so that AE shall have the same proportion to EB, as two given lines C and D have.

Draw an indefinite blank line, *AF*, to the extremity of the line *AB*, to make with it any angle; lay the line *C*, from *A* to *C*; and *D*, from *C* to *D*; and join the points *B* and *D*, by the line *BD*; through *C* draw *CE* parallel to *BD* (by prob. 8.) so is *E* the point of division.

For, by cor. 1. theo. 20. *AC* : *AD* :: *AE* : *AB*. Or, *C* : *D* :: *AE* : *EB*.

PROB. XV.

Pl. 3. *fig.* 3.

To describe a circle about a triangle ABC, or (which is the same thing) through any three points, A, B, C, which are not situated in a right line.

By prob. 4. Bisect the line *AC* by the perpendicular *DE*, and also *CB*, by the perpendicular *FG*, the point of intersection *H*, of these perpendiculars, is the centre of the circle required; from which take the distance to any of the three points *A*, *B*, *C*, and describe the circle *ABC*, and it is done.

For, by cor. to theo. 8. The lines *DE* and *FG*, must each pass through the centre, therefore, their point of intersection *H*, must be the centre.

SCHOLIUM.

By this method the centre of a circle may be found, by having only a segment of it given.

PROB. XVI.

Pl. 3. *fig.* 4.

To make an angle of any number of degrees, at the point A, of the line AB, suppose of 45 degrees.

From a scale of chords take 60 degrees, for 60° is equal to the radius (by cor. theo. 15.) and with that distance from *A*, as a centre, describe a circle from the line *AB*; take 45 degrees, the quantity of the given angle, from the same scale of chords, and lay it on that circle from *a* to *b*; through *A* and *b*, draw the line *AbC*, and the angle *A* will be an angle of 45 degrees, as required.

If the given angle be more than 90°, take its half (or divide it into any two parts less than 90) and lay them after each other on the arc, which is described with the chord of 60 degrees; through the extremity of which, and the centre, let a line be drawn, and that will form the angle required, with the given line.

PROB. XVII.

Pl. 3. *fig.* 5.

To measure a given angle, ABC.

If the lines which include the angle, be not as long as the chord of 60° on your scale, produce them to that or a greater length, and between them so produced, with the chord of 60° from *B*, describe the arc *ed*; which distance *ed*, measured on the same line of chords, gives the quantity of the angle *BAC*, as required; this is plain from def. 17.

PROB. XVIII.

Pl. 3. *fig.* 6.

To make a triangle BCE equal to a given quadrilateral figure ABCD.

Draw the diagonal *AC*, and parallel to it (by prob. 8.) *DE*, meeting *AB* produced in *E*; then draw *CE*, and *ECB* will be the triangle required.

For the triangles *ADC*, *AEC*, being upon the same base *AC*, and under the same parallel *ED*, (by cor. to theo. 13.) will be equal, therefore if *ABC* be added to each, then *ABCD* = *BEC*.

PROB. XIX.

Pl. 3. *fig.* 7.

To make a triangle DFH, equal to a given five-sided figure ABCDE.

Draw *DA* and *DB*, and also *EH* and *CF*, parallel to them (by prob. 8.) meeting *AB* produced in *H* and *F*; then draw *DH*, *DF*, and the triangle *HDF* is the one required.

For the triangle *DEA* = *DHA*, and *DBC* = *DFB* (by cor. to theo. 13.) therefore by adding these equations, *DEA* + *DBC* = *DHA* + *DFB* if to each of these *ADB* be added; then *DEA* + *ADB* + *DBC* = *ABCDE* = (*DHA* + *ABD* + *DFB*, = *DHF*.

PROB. XX.

Pl. 3. *fig.* 8.

To project the lines of chords, sines, tangents and secants, with any radius.

On the line *AB*, let a semicircle *ADB* be described; let *CDF* be drawn perpendicular to this line from the centre *C*; and the tangent *BE* perpendicular to the end of the diameter; let the quadrants, *AD*, *DB*, be each divided into 9 equal parts, every one of which will be 10 degrees; if then from the centre *C*, lines be drawn through 10, 20, 30, 40, &c. the divisions of the quadrant *BD*, and continued to *BE*, we shall there have the tangents of 10, 20, 30, 40, &c. and the secants *C* 10, *C* 20, *C* 30, &c. are transferred to the line *CF*, by describing the arcs 10, 10 : 20, 20 : 30, 30, &c. If from 10, 20, 30, &c. the divisions of the quadrant *BD*, there be let fall perpendiculars, let these be transferred to the radius *CB*, and we shall have the sines of 10, 20, 30, &c. and if from *A* we describe the arcs 10, 10 : 20, 20 : 30, 30, &c. from every division of the arc *AD*; we shall have a line of chords. The same way we may have the sine, tangent, *&c.* to every single degree on the quadrant, by subdividing each of the 9 former divisions into 10 equal parts. By this method the sines, tangents, *&c.* may be drawn to any radius; and then, after they are transferred to lines on a rule, we shall have the scales of sines, tangents, *&c.* ready for use.

MATHEMATICAL

DRAWING INSTRUMENTS.

THE strictness of geometrical demonstration admits of no other instruments, than a rule and a pair of compasses. But, in proportion as the practice of geometry was extended to the different arts, either connected with, or dependent upon it, new instruments became necessary, some to answer peculiar

purposes, some to facilitate operation, and others to promote accuracy.

As almost every artist, whose operations are connected with mathematical designing, furnishes himself with a case of drawing instruments suited to his peculiar purposes, they are fitted up in various modes, some containing more, others, fewer instruments. The smallest collection put into a case, consists of a plane scale, a pair of compasses with a moveable leg, and two spare points, which may be applied occasionally to the compasses; one of these points is to hold ink; the other, a porte crayon, for holding a piece of black-lead pencil.

What is called a full pocket case, contains the following instruments.

A pair of large compasses with a moveable point, an ink point, a pencil point, and one for dotting; either of those points may be inserted in the compasses, instead of the moveable leg.

A pair of plain compasses somewhat smaller than those with the moveable leg.

A pair of bow compasses.

A drawing pen with a protracting pin in the upper part.

A sector.

A plain scale.

A protractor.

A parallel rule.

A pencil and screw-driver.*

* Large collections are called, *magazine cases of instruments;* these generally contain

A pair of six inch compasses with a moveable leg, an ink point, a dotting point, the crayon point, so contrived as to hold a whole pencil, two additional pieces to lengthen occasionally one leg of the compasses, and thereby enable them to measure greater extents, and describe circles of a larger radius.

A pair of hair compasses.

A pair of bow compasses.

A pair of triangular compasses.

In a case with the best instruments, the protractor and plain scale are always combined. The instruments in most general use are those of six inches; instruments are seldom made longer, but often smaller. Those of six inches are, however, to be preferred, in general, before any other size; they will effect all that can be performed with the shortest ones, while, at the same time, they are better adapted to large work.

OF DRAWING COMPASSES.

Compasses are made either of silver or brass, but with steel points. The joints should always be framed of different substances; thus, one side, or part, should be of silver or brass, and the other of

A sector.
A parallel rule.
A protractor.
A pair of proportional compasses, either with or without an adjusting screw.
A pair of wholes and halves.
Two drawing pens, and a pointril.
A pair of small hair compasses, with a head similar to those of the bow compasses.
A knife, a file, key, and screw-driver, or the compasses in one piece.
A small set of fine water colours.
To these some of the following instruments are often added.
A pair of beam compasses.
A pair of gunners callipers.
A pair of elliptical compasses.
A pair of spiral ditto.
A pair of perspective compasses.
A pair of compasses with a micrometer screw.
A rule for drawing lines, tending to a centre at a great distance.
A protractor and parallel rule.
One or more parallel rules.
A pantographer, or Pentagraph.
A pair of sectoral compasses, forming, at the same time, a pair of beam and calliper compasses.

steel. The difference in the texture and pores of the two metals causes the parts to adhere less together, diminishes the wear, and promotes uniformity in their motion. The truth of the work is ascertained by the smoothness and equality of the motion at the joint, for all shake and irregularity is a certain sign of imperfection. The points should be of steel, so tempered, as neither to be easily bent or blunted; not too fine and tapering, and yet meeting closely when the compasses are shut.

As an instrument of art, compasses are so well known, that it would be superfluous to enumerate the various uses; suffice it then to say, that they are used to transfer small distances, measure given spaces, and describe arches and circles.

If the arch or circle is to be described obscurely, the steel points are best adapted to the purpose; if it is to be in ink or black lead, either the drawing pen, or crayon points are to be used.

To use a pair of compasses. Place the thumb and middle finger of the right hand in the opposite hollows in the shanks of the compasses, then press the compasses, and the legs will open a little way; this being done, push the innermost leg, with the third finger, elevating, at the same time, the furthermost, with the nail of the middle finger, till the compasses are sufficiently opened to receive the middle and third finger; they may then be extended at pleasure, by pushing the furthermost leg outwards with the middle, or pressing it inwards with the four finger. In describing circles, or arches, set one foot of the compasses on the centre, and then roll the head of the compasses between the middle and four finger, the other point pressing at the same time upon the paper. They should be held as upright as possible, and care should be taken not to press forcibly upon them, but rather to let them act by their own weight; the legs should never be so far extended, as to form

an obtuse angle with the paper or plane, on which they are used.

The ink and crayon points have a joint just under that part which fits into the compasses; by this they may be always so placed as to be set nearly perpendicular to the paper; the end of the shank of the best compasses is framed so as to form a strong spring, to bind firmly the moveable points, and prevent them from shaking. This is found to be a more effectual method than that by a screw.

Two additional pieces are often applied to these compasses; these, by lengthening the leg, enable them to strike larger circles, or measure greater extents, than they would otherwise perform, and that without the inconveniences attending longer compasses. When compasses are furnished with this additional piece, the moveable leg has a joint, that it may be placed perpendicular to the paper.

The bow compasses, are a small pair, usually with a point for ink; they are used to describe small arches or circles, which they do much more conveniently than large compasses, not only on account of their size, but also from the shape of the head, which rolls with great ease between the fingers.

Of the drawing pen and protracting pin. The pen part of this instrument is used to draw strait lines: it consists of two blades with steel points fixed to a handle; the blades are so bent, that the ends of the steel points meet, and yet leave a sufficient cavity for the ink; the blades may be opened more or less by a screw, and, being properly set, will draw a line of any assigned thickness. One of the blades is framed with a joint, that the points may be separated, and thus cleaned more conveniently; a small quantity only of ink should be put at one time into the drawing pen, and this should be placed in the cavity, between the blades, by a common pen, or feeder; the drawing pen acts

better, if the pen, by which the ink is inserted, be made to pass through the blades. To use the drawing pen, first feed it with ink, then regulate it to the thickness of the required line by the screw. In drawing lines, incline the pen a small degree, taking care, however, that the edges of both the blades touch the paper, keeping the pen close to the rule, and in the same direction during the whole operation: the blades should always be wiped very clean, before the pen is put away.

These directions are equally applicable to the ink point of the compasses, only observing, that when an arch or circle is to be described, of more than an inch radius, the point should be so bent, that the blades of the pen may be nearly perpendicular to the paper, and both of them touch it at the same time.

The protracting pin, is only a short piece of steel wire, with a very fine point, fixed at one end of the upper part of the handle of the drawing pen. It is used to mark the intersection of lines, or to set off divisions from the plotting scale, and protractor.

OF THE SECTOR.

Amidst the variety of mathematical instruments that have been contrived to facilitate the art of drawing, there is none so extensive in its use, or of such general application, as the *sector*. It is an universal scale, uniting, as it were, angles and parallel lines, the rule and the compass, which are the only means that geometry makes use of for measuring, whether in speculation or practice. The real inventor of this valuable instrument is unknown; yet of so much merit has the invention appeared, that it was claimed by *Galileo*, and disputed by nations.

This instrument derives its name from the tenth definition of the third book of *Euclid*, where he defines the sector of a circle. It is formed of two equal rules called legs; these legs are moveable about the centre of a joint, and will, consequently, by their different openings, represent every possible variety of plane angles. The distance of the extremities of these rules are the subtenses or chords, or the arches they describe.

Sectors are made of different sizes, but their length is usually denominated from the length of the legs when the sector is shut. Thus a sector of six inches, when the legs are close together, forms a rule of 12 inches when opened; and a foot sector is two feet long, when opened to its greatest extent. In describing the lines usually placed on this instrument, I refer to those commonly laid down on the best six-inch brass sectors. But as the principles are the same in all, and the differences little more than in the number of subdivisions, it is to be presumed that no difficulty will occur in the application of what is here said to sectors of a larger radius.

The scales, or lines graduated upon the faces of the instrument, and which are to be used as *sectoral lines*, proceed from the centre; and are, 1. Two scales of equal parts, one on each leg, marked LIN. or L. Each of these scales, from the great extensiveness of its use, is called the *line of lines*. 2. Two lines of *chords*, marked CHO. or C. 3. Two lines of *secants*, marked SEC. or S. A line of *polygons*, marked POL. Upon the other face, the sectoral lines are, 1. Two lines of sines marked *sin.* or S. 2. Two lines of tangents, marked *tan.* 3. Between the lines of tangents and sines, there is another line of tangents to a lesser radius, to supply the defect of the former, and extending from 45° to 75°.

Each pair of these lines (except the line of polygons) is so adjusted as to make equal angles at the centre, and consequently at whatever distance the sector be opened, the angles will be always respectively equal. That is, the distance between 10 and 10 on the line of lines, will be equal to 60 and 60 on the line of chords, 90 and 90 on the line of sines, and 45 and 45 on the line of tangents.

Besides the sectoral scales, there are others on each face, placed parallel to the outward edges, and used as those of the common plain scale. There are on the one face, 1. A line of inches. 2. A line of latitudes. 3. A line of hours. 4. A line of inclination of meridians. 5. A line of chords. On the other face, three logarithmic scales, namely, one of numbers, one of sines, and one of tangents; these are used when the sector is fully opened, the legs forming one line.

To read and estimate the divisions on the sectoral lines. The value of the divisions on most of the lines are determined by the figures adjacent to them; these proceed by tens, which constitute the divisions of the first order, and are numbered accordingly; but the value of the divisions on the line of lines, that are distinguished by figures, is entirely arbitrary, and may represent any value that is given to them; hence the figures 1, 2, 3, 4, &c. may denote either 10, 20, 30, 40; or 100, 200, 300, 400, and so on.

The line of lines is divided into ten equal parts, numbered 1, 2, 3, to 10; these may be called divisions of the first order; each of these are again subdivided into 10 other equal parts, which may be called divisions of the second order; and each of these is divided into two equal parts, forming divisions of the third order.

The divisions on all the scales are contained between four parallel lines; those of the first order

extend to the most distant; those of the third, to the least; those of the second, to the intermediate parallel.

When the whole line of lines represents 100, the divisions of the first order, or those to which the figures are annexed, represent tens; those of the second order, units; those of the third order, the halves of these units. If the whole line represents ten, then the divisions of the first order are units; those of the second, tenths, and the thirds, twentieths.

In the line of tangents, the divisions to which the numbers are affixed, are the degrees expressed by those numbers. Every fifth degree is denoted by a line somewhat longer than the rest; between every number and each fifth degree, there are four divisions, longer than the intermediate adjacent ones, these are whole degrees; the shorter ones, or those of the third order, are 30 minutes.

From the centre, to 60 degrees, *the line of sines* is divided like the line of tangents; from 60 to 70, it is divided only to every degree; from 70 to 80, to every two degrees; from 80 to 90, the division must be estimated by the eye.

The divisions on *the line of chords* are to be estimated in the same manner as the tangents.

The *lesser line of tangents* is graduated every two degrees from 45 to 50; but from 50 to 60, to every degree; from 60 to the end, to half degrees.

The *line of secants* from 0 to 10, is to be estimated by the eye; from 20 to 50 it is divided to every two degrees; from 50 to 60, to every degree; and from 60 to the end, to every half degree.

The solution of questions on the sector is said to be *simple*, when the work is begun and ended on the same line; *compound*, when the operation begins on one line, and is finished on the other.

The operation varies also by the manner in which the compasses are applied to the sector. If a mea-

sure be taken on any of the sectoral lines, beginning at the centre, it is called *a lateral distance.* But if the measure be taken from any point in one line, to its corresponding point on the line of the same denomination, on the other leg, it is called *a transverse* or *parallel distance.*

The divisions of each sectoral line are bounded by three parallel lines; the innermost of these is that on which the points of the compasses are to be placed, because this alone is the line which goes to the centre, and is alone, therefore, the sectoral line.

We shall now proceed to give a few general instances of the manner of operating with the sector.

Multiplication by the line of lines. Make the lateral distance of one of the factors the parallel distance of 10; then the parallel distance of the other factor is the product.

Example. Multiply 5 by 6, extend the compasses from the centre of the sector to 5 on the primary divisions, and open the sector till this distance become the parallel distance from 10 to 10 on the same divisions; then the parallel distance from 6 to 6, extended from the centre of the sector, shall reach to 3, which is now to be reckoned 30. At the same opening of the sector, the parallel distance of 7 shall reach from the centre to 35, that of 8 shall reach from the centre to 40, &c.

Division by the line of lines. Make the lateral distance of the dividend the parallel distance of the divisor, the parallel distance of 10 is the quotient. Thus, to divide 30 by 5, make the lateral distance of 30, viz. 3 on the primary divisions, the parallel distance of 5 of the same divisions; then the parallel distance of 10, extended from the centre, shall reach to 6.

Proportion by the line of lines. Make the lateral distance of the second term the parallel distance

of the first term; the parallel distance of the third term is the fourth proportional.

Example. To find a fourth proportional to 8, 4, and 6, take the lateral distance of 4, and make it the parallel distance of 8; then the parallel distance of 6, extended from the centre, shall reach to the fourth proportional 3.

In the same manner a third proportional is found to two numbers. Thus, to find a third proportional to 8 and 4, the sector remaining as in the former example, the parallel distance of 4, extended from the centre, shall reach to the third proportional 2. In all these cases, if the number to be made a parallel distance be too great for the sector, some aliquot part of it is to be taken, and the answer multiplied by the number by which the first number was divided. Thus, if it were required to find a fourth proportional to 4, 8, and 6; because the lateral distance of the second term 8 cannot be made the parallel distance of the first term 4, take the lateral distance of 4, viz. the half of 8, and make it the parallel distance of the first term 4; then the parallel distance of the third term 6, shall reach from the centre to 6, viz. the half of 12. Any other aliquot part of a number may be used in the same way. In like manner, if the number proposed be too small to be made the parallel distance, it may be multiplied by some number, and the answer is to be divided by the same number.

To protract angles by the line of Chords. Case 1. When the given degrees are under 60. 1. With any radius on a centre, describe the arch. 2. Make the same radius a transverse distance between 60 and 60 on the line of chords. 3. Take out the transverse distance of the given degrees, and lay this on the arch, which will mark out the angular distance required.

Case 2. When the given degrees are more than

60. 1. Open the sector, and describe the arch as before. 2. Take $\frac{1}{2}$ or $\frac{1}{3}$ of the given degrees, and take the transverse distance of this $\frac{1}{2}$ or $\frac{1}{3}$, and lay it off twice, if the degrees were halved, three times if the third was used as a transverse distance.

Case 3. When the required angle is less than 6 degrees; suppose 3. 1. Open the sector to the given radius, and describe the arch as before. 2. Set off the radius. 3. Set off the chord of 57 degrees backwards, which will give the arc of three degrees.

Given the radius of a circle, (suppose equal to two inches,) required the sine and tangent of 28° 30′ *to that radius.*

Solution. Open the sector so that the transverse distance of 90 and 90 on the sines, or of 45 and 45 on the tangents, may be equal to the given radius, viz. two inches; then will the transverse distance of 38° 30′, taken from the sines, be the length of that sine to the given radius; or if taken from the tangents; will be the length of that tangent to the given radius.

But if the secant of 28° 30′ *was required?*

Make the given radius, two inches, a transverse distance to 0 and 0, at the beginning of the line of secants; and then take the transverse distance of the degrees wanted, viz. 28° 30′.

A tangent greater than 45° *(suppose* 60°*) is found thus.*

Make the given radius, suppose two inches, a transverse distance to 45 and 45 at the beginning of the scale of upper tangents; and then the required number 60°00′ may be taken from this scale.

Given the length of the sine, tangent, or secant of any degrees; to find the length of the radius to that sine, tangent, or secant.

Make the given length a transverse distance to its given degrees on its respective scale: then,

In the sines. The transverse distance of 90 and 90 will be the radius sought.

In the lower tangents. The transverse distance of 45 and 45, near the end of the sector, will be the radius sought.

In the upper tangents. The transverse distance of 45 and 45, taken towards the centre of the sector on the line of upper tangents, will be the centre sought.

In the secant. The transverse distance of 0 and 0, or the beginning of the secants, near the centre of the sector, will be the radius sought.

Given the radius and any line representing a sine, tangent, or secant; to find the degrees corresponding to that line.

Solution. Set the sector to the given radius, according as a sine, or tangent, or secant is concerned.

Take the given line between the compasses; apply the two feet transversely to the scale concerned, and slide the feet along till they both rest on like divisions on both legs; then will those divisions shew the degrees and parts corresponding to the given line.

To find the length of a versed sine to a given number of degrees, and a given radius.

Make the transverse distance of 90 and 90 on the sines, equal to the given radius.

Take the transverse distance of the sine complement of the given degrees.

If the given degrees are less than 90, the difference between the sine complement and the radius gives the versed sine.

If the given degrees are more than 90, the sum of the sine complement and the radius gives the versed sine.

To open the legs of the sector, so that the corres-

ponding double scales of lines, chords, sines, and tangents, may make each a right angle.

On the lines, make the lateral distance 10, a distance between eight on one leg, and six on the other leg.

On the sines, make the lateral distance 90 a transverse distance from 45 to 45; or from 40 to 50; or from 30 to 60; or from the sine of any degrees to their complement.

Or on the sines, make the lateral distance of 45 a transverse distance between 30 and 30.

OF THE PLAIN SCALE.

The divisions laid down on the plain scale are of two kinds, the one having more immediate relation to the circle and its properties, the other being merely concerned with dividing straight lines.

Though arches of a circle are the most natural measures of an angle, yet in many cases right lines are substituted, as being more convenient; for the comparison of one right line with another, is more natural and easy, than the comparison of a right line with a curve; hence it is usual to measure the quantities of angles not by the arch itself, which is described on the angular point, but by certain lines described about that arch.

The lines laid down on the plain scales for the measuring of angles, or the protracting scales, are, 1. A line of *chords* marked CHO. 2. A line of *sines* marked SIN. of *tangents* marked TAN. of *semitangents* marked ST. and of *secants* marked SEC. this last is often upon the same line as the sines, because its gradations do not begin till the sines end.

There are two other scales, namely, the *rhumbs,* marked RU. and *longitudes,* marked LON. Scales of latitude and hours are sometimes put upon the

plain scale; but, as dialling is now but seldom studied, they are only made to order.

The divisions used for measuring straight lines are called *scales of equal parts*, and are of various lengths for the convenience of delineating any figure of a large or smaller size, according to the fancy or purposes of the draughts-man. They are, indeed, nothing more than a measure in miniature for laying down upon paper, &c. any known measure, as chains, yards, feet, &c. each part on the scale answering to one foot, one yard, &c. and the plan will be larger or smaller, as the scale contains a smaller or a greater number of parts in an inch. Hence a variety of scales is useful to lay down lines of any required length, and of a convenient proportion with respect to the size of the drawing. If none of the scales happen to suit the purpose, recourse should be had to the *line of lines* on the sector; for, by the different openings of that instrument, a line of any length may be divided into as many equal parts as any person chooses.

Scales of equal parts are divided into two kinds, the one simple, the other diagonally divided.

Six of the simply divided scales are generally placed one above another upon the same rule; they are divided into as many equal parts as the length of the rule will admit of; the numbers placed on the right hand, shew how many parts in an inch each scale is divided into. The upper scale is sometimes shortened for the sake of introducing another, called the line of chords.

The first of the larger, or primary divisions, on every scale is subdivided into 10 equal parts, which small parts are those which give a name to the scale: thus it is called a scale of 20, when 20 of these divisions are equal to one inch. If, therefore, these lesser divisions be taken as units, and each represents one league, one mile, one chain, or one yard,

&c. then will the larger divisions be so many tens; but if the subdivisions are supposed to be tens, the larger divisions will be hundreds.

To illustrate this, suppose it were required to set off from either of the scales of equal parts $\frac{36}{10}$, 36, or 360 parts, either miles or leagues. Set one foot of your compasses on 3, among the larger or primary divisions, and open the other point till it falls on the 6th subdivision, reckoning backwards or towards the left hand. Then will this extent represent, $\frac{36}{10}$ 36, or 360 miles or leagues, &c. and bear the same proportion in the plan as the line measured does to the thing represented.

To adapt these scales to feet and inches, the first primary division is often duodecimally divided by an upper line; therefore, to lay down any number of feet and inches, as for instance, eight feet eight inches, extend the compasses from eight of the larger to eight of the upper small ones, and that distance laid down on the plan will represent eight feet eight inches.

Of the scale of equal parts diagonally divided. The use of this scale is the same as those already described. But by it a plane may be more accurately divided than by the former; for any one of the larger divisions may by this be subdivided into 100 equal parts; and, therefore, if the scale contains 10 of the larger divisions, any number under 1000 may be laid down with accuracy.

The diagonal scale is seldom placed on the same side of the rule with the other plotting scale. The first division of the diagonal scale, if it be a foot long, is generally an inch divided into 100 equal parts, and at the opposite end there is usually half an inch divided into an 100 equal parts. If the scale be six inches long, one end has commonly half an inch, the other a quarter of an inch subdivided into 100 equal parts.

The nature of this scale will be better understood by considering its construction. For this purpose:

First. Draw eleven parallel lines at equal distances; divide the upper of these lines into such a number of equal parts, as the scale to be expressed is intended to contain; from each of these divisions draw perpendicular lines through the eleven parallels.

Secondly. Subdivide the first of these divisions into ten equal parts, both in the upper and lower lines.

Thirdly. Subdivide again each of these subdivisions, by drawing diagonal lines from the 10th below to the 9th above; from the 8th below to the 7th above; and so on, till from the first below to the 0 above; by these lines each of the small divisions is divided into ten parts, and, consequently, the whole first space into 100 equal parts; for, as each of the subdivisions is one-tenth part of the whole first space or division, so each parallel above it is one-tenth of such subdivision, and, consequently, one-hundreth part of the whole first space: and if there be ten of the larger divisions, one-thousandth part of the whole space.

If, therefore, the larger divisions be accounted as units, the first subdivisions will be tenth parts of an unit, and the second, marked by the diagonal upon the parallels, hundreth parts of the unit. But, if we suppose the larger divisions to be tens, the first subdivisions will be units, and the second tenths. If the larger are hundreds, then will the first be tens, and the second units.

The numbers therefore, 576, 57,6, 5,76, are all expressible by the same extent of the compasses: thus setting one foot in the number five of the larger divisions, extend the other along the sixth parallel to the seventh diagonal. For, if the five

larger divisions be taken for 500, seven of the first subdivisions will be 70, which upon the sixth parallel, taking in six of the second subdivisions for units, makes the whole number 576. Or, if the five larger divisions be taken for five tens, or 50, seven of the first subdivisions will be seven units, and the six second subdivisions upon the sixth parallel, will be six tenths of an unit. Lastly, if the five larger divisions be only esteemed as five units, then will the seven first subdivisions be seven tenths, and the six second subdivisions be the six hundredth parts of an unit.

Of the line of chords. This line is used to set off an angle from a given point in any right line, or to measure the quantity of an angle already laid down.

Thus to draw a line that shall make with another line an angle, containing a given number of degrees, suppose 40 degrees.

Open your compasses to the extent of 60 degrees upon the line of chords, (which is always equal to the radius of the circle of projection,) and setting one foot in the angular point, with that extent describe an arch; then taking the extent of 40 degrees from the said chord line, set it off from the given line on the arch described; a right line drawn from the given point, through the point marked upon the arch, will form the required angle.

The degrees contained in an angle already laid down, are found nearly in the same manner; for instance, to measure an angle. From the centre describe an arch with the chord of 60 degrees, and the length of the arch, contained between the lines measured on the line of chords, will give the number of degrees contained in the angle.

If the number of degrees are more than 90, they must be measured upon the chords at twice: thus, if 120 degrees were to be practised, 60 may be taken from the chords, and those degrees be laid off

twice upon the arch. Degrees taken from the chords are always to be counted from the beginning of the scale.

Of the rhumb line. This is, in fact, a line of chords constructed to a quadrant divided into eight parts or points of the compass, in order to facilitate the work of the navigator in laying down a ship's course.

Of the line of longitudes. The line of longitudes is a line divided into sixty unequal parts, and so applied to the line of chords, as to shew, by inspection, the number of equatorial miles contained in a degree on any parallel of latitude. The graduated line of chords is necessary, in order to shew the latitudes; the line of longitude shews the quantity of a degree on each parallel in sixtieth parts of an equatorial degree, that is, miles.

The lines of tangents, semitangents, and secants, serve to find the centres and poles of projected circles in the stereographical projection of the sphere.

The line of sines is principally used for the orthographic projection of the sphere.

The lines of latitudes and hours are used conjointly, and serve very readily to mark the hour lines in the construction of dials; they are generally on the most complete sorts of scales and sectors; for the uses of which see treatises on dialling.

OF THE PROTRACTOR.

This is an instrument used to protract, or lay down an angle containing any number of degrees, or to find how many degrees are contained in any given angle. There are two kinds put into cases of mathematical drawing instruments; one in the form of a semicircle, the other in the form of a parallelogram. The circle is undoubtedly the only natural measure of angles; when a straight line is therefore used, the divisions thereon are derived

from a circle, or its properties, and the straight line is made use of for some relative convenience: it is thus the parallelogram is often used as a protractor, instead of the semicircle, because it is in some cases more convenient, and that other scales, &c. may be placed upon it.

The semicircular protractor, is divided into 180 equal parts or degrees, which are numbered at every tenth degree each way, for the conveniency of reckoning either from the right towards the left, or from the left towards the right; or the more easily to lay down an angle from either end of the line, beginning at each end with 10, 20, &c. and proceeding to 180 degrees. The edge is the diameter of the semicircle, and the mark in the middle points out the centre, in a *protractor in the form of a parallelogram*: the divisions are as in the semicircular one, numbered both ways; the blank side represents the diameter of a circle. The side of the protractor to be applied to the paper is made flat, and that whereon the degrees are marked, is chamfered or sloped away to the edge, that an angle may be more easily measured, and the divisions set off with greater exactness.

Application of the protractor to use. 1. *A number of degrees being given, to protract, or lay down an angle, whose measure shall be equal thereto.*

Thus, to lay down an angle of 60 degrees from the point of a line, apply the diameter of the protractor to the line, so that the centre thereof may coincide exactly with the extremity; then with a protracting pin make a fine dot against 60 upon the limb of the protractor; now remove the protractor, and draw a line from the extremity through that point, and the angle contains the given number of degrees.

2. *To find the number of degrees contained in a given angle.*

Place the centre of the protractor upon the angular point, and the fiducial edge, or diameter, exactly upon the line; then the degree upon the limb that is cut by the line will be the measure of the given angle, which, in the present instance, is found to be 60 degrees.

3. *From a given point in a line, to erect a perpendicular to that line.*

Apply the protractor to the line, so that the centre may coincide with the given point, and the division marked 90 may be cut by the line; then a line drawn against the diameter of the protractor will be the perpendicular required.

OF PARALLEL RULES.

Parallel lines occur so continually in every species of mathematical drawing, that it is no wonder so many instruments have been contrived to delineate them with more expedition than could be effected by the general geometrical methods. For this purpose, *rules* of various constructions have been made; and particularly recommended by their inventors; their use however is so apparent as to need no explanation.

GUNTER'S SCALE.

The scale generally used is a ruler of two feet in length, having drawn upon it equal parts, chords, sines, tangents, secants, &c. These are contained on one side of the scale, and the other side contains the logarithms of these numbers. *Mr. Edmund Gunter* was the first who applied the logarithms of numbers, and of sines and tangents to straight lines drawn on a scale or ruler; with which, proportions in common numbers, and trigonometry, may be solved by the application of a pair of compasses

only. The method is founded on this property, *That the logarithms of the terms of equal ratios are equidifferent.* This was called Gunter's Proportion, and Gunter's Line; hence the scale is generally called the Gunter.

Of the Logarithmical Lines, or Gunter's Scale.

The logarithmical lines, on *Gunter's* scale, are the eight following:

*S*Rhumb*, or fine rhumbs, is a line containing the logarithms of the natural sines of every point and quarter point of the compass, numbered from a brass pin on the right hand towards the left with 8, 7, 6, 5, 4, 3, 2, 1.

*T*Rhumb*, or tangent rhumbs, also corresponds to the logarithm of the tangent of every point and quarter point of the compass. This line is numbered from near the middle of the scale with 1. 2. 3. 4 towards the right hand, and back again with the numbers 5, 6, 7 from the right hand towards the left. To take off any number of points below four, we must begin at 1, and count towards the right hand; but to take off any number of points above four, we must begin at four, and count towards the left hand.

Numbers, or the line of numbers, is numbered from the left hand of the scale towards the right, with 1, 2, 3, 4, 5, 6, 7, 8, 9, 1 which stands exactly in the middle of the scale; the numbers then go on 2, 3, 4, 5, 6, 7, 8, 9, 10 which stands at the right hand end of the scale. These two equal parts of the scale are divided equally, the distance between the first or left hand 1, and the first 2, 3, 4, &c. is exactly equal to the distance between the middle 1 and the numbers 2, 3, 4, &c. which follow it. The subdivisions of these scales are likewise similar, viz. they are each one-tenth of the primary divisions, and are distinguished by lines of about half the length of the primary divisions.

These subdivisions are again divided into ten parts, where room will permit; and where that is not the case, the units must be estimated, or guessed at, by the eye, which is easily done by a little practice.

The primary divsions on the second part of the scale, are estimated according to the value set upon the unit on the left hand of the scale: If you call it one, then the first 1, 2, 3, &c. stand for 1, 2, 3, &c. the middle 1 is 10, and the 2. 3. 4. &c. following stand for 20, 30, 40, &c. and the ten at the right hand is 100: If the first 1 stand for 10, the first 2, 3, 4, &c. must be counted 20, 30, 40, &c. the middle 1 will be 100, the second 2, 3, 4, 5, &c. will stand for 200, 300, 400, 500, &c. and the ten at the right hand for 1000.

If you consider the first 1 as $\frac{1}{10}$ of an unit, the 2, 3, 4, &c. following will be $\frac{2}{10}$, $\frac{3}{10}$, $\frac{4}{10}$, &c. the middle 1 will stand for an unit, and the 2, 3, 4, &c. following will stand for 2, 3, 4, &c. also the division at the right-hand end of the scale will stand for 10. The intermediate small divisions must be estimated according to the value set upon the primary ones.

Sine. The line of sines is numbered from the left hand of the scale towards the right, 1, 2, 3, 4, 5, &c. to 10; then 20, 30, 40, &c. to 90, where it terminates just opposite 10 on the line of numbers.

Versed sine. This line is placed immediately under the line of sines, and numbered in a contrary direction, viz. from the right hand towards the left 10, 20, 30, 40, 50, to about 169; the small divisions are here to be estimated according to the number of them to a degree. By comparing the line of versed sines with the line of sines, it will appear that the versed sines do not belong to the arches with which they are marked, but are the half versed sines of their supplements. Thus, what is marked the versed sine of 90 is only half the versed sine of 90,

the versed sine of 120° is half the versed sine of 60°, and the versed sine marked 100° is half the versed sine of 80°, &c.

The versed sines are numbered in this manner to render them more commodious in the solution of trigonometrical, and astronomical problems.

Tangents. The line of tangents begins at the left hand, and is numbered 1, 2, 3, &c. to 10, then 20, 30, 45, where there is a little brass pin just under 90 in the line of sines; because the sine of 90° is equal to the tangent of 45°. It is numbered from 45° towards the left hand 50, 60, 70, 80, &c. The tangents of arches above 45° are therefore counted backward on the line, and are found at the same points of the line as the tangents of their complements.

Thus, the division at 40 represents both 40 and 50, the division at 30 serves for 30 and 60, &c.

Meridional Parts. This line stands immediately above a line of equal parts, marked *Equal Pt.* with which it must always be compared when used. The line of equal parts is marked from the right hand to the left with 0, 10, 20, 30, &c.; each of these large divisions represents 10 degrees of the equator, or 600 miles. The first of these divisions is sometimes divided into 40 equal parts, each representing 15′ minutes or miles.

The extent from the brass pin on the scale of meridional parts to any *division* on that scale, applied to the line of equal parts, will give (in degrees) the meridional parts answering to the latitude of that *division.* Or the extent from any *division* to another, on the line of meridional parts, applied to the line of equal parts, will give the meridional difference of latitude between the two places denoted by the *divisions.* These degrees are reduced to leagues by multiplying by 20, or to miles by multiplying by 60.

The use of the logarithmical lines on Gunter's Scale.

By these lines and a pair of compasses, all the problems of Trigonometry, &c. may be solved.

These problems are all solved by proportion; Now in natural numbers, the quotient of the first term by the second is equal to the quotient of the third by the fourth: therefore logarithmically speaking the difference between the first and second term is equal to the difference between the third and fourth, consequently on the lines on the scale, the distance between the first and second term will be equal to the distance between the third and fourth. And for a similar reason, because four proportional quantities are alternately proportional, the distance between the first and third terms, will be equal to the distance between the second and fourth. Hence the following

General Rule.

The extent of the compasses from the first term to the second, will reach, in this same direction, from the third to the fourth term. Or, the extent of the compasses from the first term to the third, will reach, in the same direction, from the second to the fourth.

By the same direction in the foregoing rule, is meant that if the second term lie on the right hand of the first, the fourth will lie on the right hand of the third, and the contrary. This is true, except the two first or two last terms of the proportion are on the line of tangents, and neither of them under 45°; in this case the extent on the tangents is to be made in a contrary direction: For had the tangents above 45° been laid down in their proper direction, they would have extended beyond the length of the scale towards the right hand; they are therefore as it were folded back up-

on the tangents below 45°, and consequently lie in a direction contrary to their proper and natural order.

If the two last terms of a proportion be on the line of tangents, and one of them greater and the other less than 45°; the extent from the first term to the second will reach from the third beyond the scale. To remedy this inconvenience, apply the extent between the two first terms from 45° backward upon the line of tangents, and keep the left hand point of the compasses where it falls; bring the right hand point from 45° to the third term of the proportion; this extent now in the compasses applied from 45° backward will reach to the fourth term, or the tangent required. For, had the line of tangents been continued forward beyond 45°, the divisions would have fallen above 45° forward; in the same manner as they fall under 45° backward.

SECTION V.

TRIGONOMETRY.

The word *Trigonometry* signifies the *measuring of triangles*. But, under this name is generally comprehended the art of determining the positions and dimensions of the several unknown parts of extension, by means of some parts, which are already known. If we conceive the different points, which may be represented in any space, to be joined together by right lines, there are three things offered for our consideration; 1. the length of these lines; 2. the angles which they form with one another; 3. the angles formed by the planes, in which these lines are drawn, or are supposed to be traced. On the comparison of these three objects,

depends the solution of all questions, that can be proposed concerning the measure of extension, and its parts; and the art of determining all these things from the knowledge of some of them, is reduced to the solution of these two general questions.

1. Knowing three of the six parts, the sides and angles—which constitute a rectilineal triangle; to find the other three.

2. Knowing three of the six parts, which compose a spherical triangle; that is a triangle formed on the surface of a sphere by three arches of circles, which have their centre in the centre of the same sphere—to find the other three.

The first question is the object of what is called Plane Trigonometry, because the six parts, considered here, are in the same plane: it is also denominated Rectilineal Trigonometry. The second question belongs to Spherical Trigonometry, wherein the six parts are considered in different planes. But the only object here is to explain the solutions of the former question: viz.

Plane Trigonometry.

Plane Trigonometry is that branch of geometry, which teaches how to determine, or calculate three of the six parts of a rectilineal triangle by having the other three parts given or known. It is usually divided into Right angled and Oblique angled Trigonometry, according as it is applied to the mensuration of Right or Oblique angled Triangles.

In every triangle, or case in trigonometry, three of the parts must be given, and one of these parts, at least, must be a side; because, with the same angles, the sides may be greater or less in any proportion.

Right Angled Plane Trigonometry.

Pl. 5. Fig. 1.

1. In every right-angled plane triangle *ABC*, if the hypothenuse *AC* be made the radius, and with it a circle, or an arc of one, be described from each end; it is plain (from def. 20.) that *BC* is the sine of the angle *A*, and *AB* is the sine of the angle *C*; that is, the legs are the sines of their opposite angles.

Fig. 2.

If one leg *AB* be made the radius, and with it, on the point *A*, an arc be described; then *BC* is the tangent, and *AC* is the secant of the angle *A*, by def. 22 and 25.

Fig. 3.

3. If *BC* be made the radius, and an arc be described with it on the point *C*; then is *AB* the tangent, and *AC* is the secant of the angle *C*, as before.

Because the sine, tangent, or secant of any given arc, in one circle, is to the sine, tangent, or secant of a like arc (or to one of the like number of degrees) in another circle; as the radius of the one is to the radius of the other; therefore the sine, tangent, or secant of any arc is proportional to the sine, tangent, or secant of a like arc, as the radius of the given arc is to 10.000000, the radius from whence the logarithmic sines, tangents, and secants, in most tables, are calculated, that is;

If *AC* be made the radius, the sines of the angle *A* and *C*, described by the radius *AC*, will be proportional to the sines of the like arcs, or angles in the circle, that the tables now mentioned were

calculated for. So if BC was required, having the angles and AB given, it will be,

Fig. 1.

As $S.C : AB :: S.A : BC$.

That is, as the sine of the angle C in the tables, is to the length of AB; (or sine of the angle C, in a circle whose radius is AC;) so is the sine of the angle A in the tables, to the length of BC. (or sine of the same angle, in the circle, whose radius is AC.)

In like manner the tangents and secants represented by making either leg the radius, will be proportional to the tangents and secants of a like arc, as the radius of the given arc is to 10.000000, the radius of the tables aforesaid.

Hence it is plain, that if the name of each side of the triangle be placed thereon, a proportion will arise to answer the same end as before: thus if AC be made the radius, let the word radius be written thereon; and as BC and AB, are the sines of their opposite angles; upon the first let $S.A$, or sine of the angle A, and on the other let $S.C$, or sine of the angle C, be written. Then,

When a side is required, it may be obtained by this proportion, viz.

As the name of the side given
is to the side given,
So is the name of the side required
to the side required.

Thus, if the angles A and C, and the hypothenuse AC were given, to find the sides; the proportion will be

Fig. 1.

1. $R : AC :: S.A : BC$.

That is, as radius is to *AC*, so is the sine of the angle *A*, to *BC*. And,

2. *R* : *AC* : : *S.C* : *AB*.

That is, as radius is to *AC*, so is the sine of the angle *C* to *AB*.

When an angle is required, we use this proportion, viz.

As the side that is made the radius,
is to radius,
So is the other given side,
to its name.

Thus, if the legs were given to find the angle *A*, and if *AB* be made the radius, it will be

Fig. 2.

AB : *R* : : *BC* : *TA*.

That is, as *AB*, is to radius, so is *BC*, to the tangent of the angle *A*.

After the same manner, the sides or angles of all right angled plane triangles may be found, from their proper data.

We here, in plate 4, give all the proportion requisite for the solution of the six cases in right-angled trigonometry; making every side possible the radius.

In the following triangles this mark — in an angle denotes it to be known, or the quantity of degrees it contains to be given; and this mark′ on a side, denotes its length to be given in feet, yards, perches, or miles, &c. and this mark°, either in an angle or on a side, denotes the angle or side to be required.

From these proportions it may be observed; that to find a side, when the angles and one side are given, any side may be made the radius; and

to find an angle, one of the given sides must be made the radius. So that in the 1st, 2d, and 3d cases, any side as well required as given may be made the radius, and in the first statings of the 4th, 5th, and 6th cases, a given side only is made the radius.

RIGHT ANGLED TRIANGLES.

CASE I.

The angles and hypothenuse given, to find the base and perpendicular.

Pl. 5. *Fig.* 4.

In the right angled triangle *ABC*, suppose the angle $A = 46°. 30'$. and consequently the angle $C = 43°. 30'$. (by cor. 2. theo. 5.); and *AC* 250 parts, (as feet, yards, miles, &c.) required the sides *AB* and *BC*.

1st. BY CONSTRUCTION.

Make an angle of 46°. 30′, in blank lines, (by prob. 16. geom.) as *CAB*; lay 250, which is the given hypothenuse, from a scale of equal parts, from *A* to *C*; from *C*, let fall the perpendicular (*BC*, by prob. 7. geom.) and that will constitute the triangle *ABC*. Measure the lines *BC*, and *AB*, from the same scale of equal parts that *AC* was taken from; and you have the answer.

2d. BY CALCULATION.

1. *Making AC the radius*, the required sides are found by these propositions, as in plate 4, case 1.

$$R : AC :: S.A : BC.$$
$$R : AC :: S.C : AB.$$

That is, as radius,	$=90°$	10.000000
is to AC	$=250$	2.397940
So is the sine of A$=46°.\ 30'$		9.860562
to BC,	$=181.\ 4$	2.258502

As radius,	$=90°$	10.000000
is to AC,	$=250$	2.397940
So is the sine of $C=43°.\ 30'$		9.837812
to AB,	$=172.\ 1$	2.235752

If from the sum of the second and third logs. that of the first be taken, the number will be the log. of the fourth; the number answering to which will be the thing required; but when the first log. is radius, or 10.000000, reject the first figure of the sum of the other two logs. (which is the same thing as to subtract 10.000000 ;) and that will be the log. of the thing required.

2. *Making AB the radius.*

Secant $A : AC :: R : AB$.
Secant $A : AC :: T.A : BC$.

That is, As the secant of $A=46°\ 30'$		10.162188
is to AC,	$=250$	2.397940
So is the radius	$=90°$	10.000000
		12.397940
to AB,	$=172.\ 1$	2.235762

As the secant of A	$=46° 30'$	10.162188
is to AC,	$=$ 250	2.397940
So is the tangent of A	$=46° 30'$	10.022750
		12.420690
to BC,	$=181.34.$	2.258502

3. *Making BC the radius.*

Sec. $C : AC :: R : BC.$
Sec. $C : AC :: T.C : AB.$

That is, as the secant of C	$=43° 30'$	10.139438
is to AC,	$=$ 250	2.397940
So is radius	$=$ 90°	10.000000
		12.397940
to BC,	$=181.34$	2.258502
As the secant of C	$=43° 30'$	10.139438
is to AC,	$=$ 250	2.397940
So is the tangent of C	$=43° 30'$	9.977250
		12.375190
to AB,	$=$ 172. 1	2.235752

Or, having found one side, the other may be obtained by cor. 2. theo. 14. sect. 4.

3d. *By Gunter's scale.*

The first and third terms in the foregoing proportions, being of a like nature, and those of the second and fourth being also like to each other; and the proportions being direct ones, it follows; that if the third term be greater or less than the first, the fourth term will be also greater or less

than the second; therefore the extent in your compasses, from the first to the third term, will reach from the second to the fourth.

Thus, to extend the first of the foregoing proportions;

1. Extend from 90° to 46° 30′, on the line of sines; that distance will reach from 250 on the line of numbers, to 181, for *BC*.

2. Extend from 90° to 43° 30′, on the line of sines; that distance will reach from 250 on the line of numbers, to 172, for *AB*.

If the first extent be from a greater to a less number; when you apply one point of the compasses to the second term, the other must be turned to a less; and the contrary.

By def. 20. sect. 4. The sine of 90° is equal to the radius; and the tangent of 45° is also equal to the radius; because if one angle of a right angled triangle be 45°, the other will be also 45°; and thence (by the lemma preceding theo. 7. sect. 4.) the tangent of 45° is equal to the radius: for this reason the line of numbers of 10.000000, the sine of 90°, and tangent of 45° being all equal, terminate at the same end of the scale.

The two first statings of this case, answers the question without a secant: the like will be also made evident in all the following cases.

4th. *Solution by Natural Sines.*

From the foregoing analogies, or statements, it

is obvious that if the hypothenuse be multiplied by the natural sine of either of the acute angles, the product will be the length of the side opposite to that angle; and multiplied by the natural cosine of the same angle, the product will be the length of the other side, or that which is contiguous to the angle. Thus:

the given ang.=47° 30′.

Nat. Sine=.725374	Nat. Cos.=.688355
Hyp.= 250	250
36268700	34417750
1450748	1376710
Perpend.=181.343500	Base=172.088750

CASE II.

The base and angles given; to find the perpendicular and hypothenuse.

Pl. 5. fig. 5.

In the triangle *ABC* there is the angle *A* 42° 20′, and of course the angle *C* 47° 40′ (by cor. 2. theo. 5,) and the side *AB* 190, given; to find *BC* and *AC*.

1st. *By Construction.*

Make the angle *CAB* (by prob. 16. sect. 4.) in blank lines, as before. From a scale of equal parts lay 190 from *A* to *B*: on the point *B*, erect a perpendicular *BC* (by prob. 5. sect. 4.) the point where this cuts the other blank line of the angle, will be *C*: so is the triangle *ABC* constructed; let *AC* and *BC* be measured from the same scale of equal parts that *AB* was taken from, and the answers are found.

2d. *By Calculation.*

1. *Making AC the radius.*

$S.C : AB :: R : AC.$
$S.C : AB :: S.A : BC.$

That is, as the sine of C	$=47°\ 40'$		9.868785
is to AB,	=	190	2.278754
So is radius	=	90°	10.000000
			12.278754
to AC	=	257	2.409969

As the sine of C	$=47°\ 40'$		9.868785
is to AB,	=	190	2.278754
So is the sine of A	$=42°\ 20'$		9.828301
			12.107055
to BC,	=173. 1		2.238270

2. *Making AB the radius.*

$R : AB :: T.A : BC.$
$R : AB ::$ Sec. $A : AC.$

That is, as radius	=	90°	10.000000
is to AB,	=	190	2.278754
So is the tangent of A	$=42°\ 20'$		9.959516
to BC,	=173. 1		2.238270
As radius	=90		10.000000
is to AB,	=190		2.278754
So is the secant of A	$=42°\ 20'$		10.131215
to AC,	=	257	2.409969

3. *Making BC the radius.*

$T.\,C : AB :: \text{Sec.}\,C : AC.$
$T.\,C : AB :: R : BC.$

That is, as the tangent of	$C=47°\ 40'$	10.040484
is to AB,	$=$ 190	2.278754
So is the Secant of	$C=47°\ 40'$	10.171699
		12.450453
to AC,	$=$ 257	2.409969
As the tangent of	$C=47°\ 40$	10.040484
is to AB,	$=$ 190	2.278754
So is the radius	$=90°$	10.000000
		12.278754
to BC	$=$ 173. 1	2.238270

Or, having found one of the required sides, the other may be obtained, by one, or the other of the cors. to theo. 14. sect. 4.

3d. *By Gunter's Scale:*

1. When AC is made the radius.

Extend from 47° 40′, to 90° on the line of sines; that distance will reach from 190 to 257, on the line of numbers, for AC.

2. When AB is made the radius, the first stating is thus performed:

Extend from 45° on the tangents (for the tangent of 45° is equal to the radius, or to the sine of 90° as before) to 42° 20′; that extent will reach from 190, on the line of numbers, to 173, for BC.

3. When BC is made the radius, the second stating is thus performed:

Extend from 47° 40′ on the line of tangents, to 45°, or radius; that extent will reach from 190 to 173, on the line of numbers, for BC; for the tangent of 47° 40′, is more than the radius, therefore the fourth number must be less than the second, as before.

The two first statings of this case, answer the question without a secant.

4th. Solution by Natural Sines.

$$\frac{AB \times R.}{S \text{ of } C.} = AC; \text{ and } \frac{AB \times S \text{ of } A}{S \text{ of } C.} = BC.$$

Nat. S of C, side $AB \times R$.

Thus .739239) 190.000000 (257.02 &c.=AC.

```
               147.8478
               --------
                 4215220
                 3696195
                 -------
                  5190250
                  5174673
                  -------
                   1557700
                   1478478
```

and,

.673443=Nat. S. of A.
190=side AB.

60609870

Nat. *S.* of *C.* 673443

```
.739239) 127.954170 (173.09=BC.
         739239
         -------
         5403027
         5174673
         -------
          2283540
          2217717
          -------
           6502300
           6653151
```

CASE III.

The angles and perpendicular given; to find the base and hypothenuse.

Pl. 5. *fig.* 6.

In the triangle *ABC*, there is the angle *A* 40°, and consequently the angle *C* 50°, with *BC* 170, given: to find *AC* and *AB*.

1*st.* *By Construction.*

Make an angle *CAB* of 40° in blank lines; (by prob. 16. sect. 4.) with *BC* 170, from a line of equal parts draw the lines *EF* parallel to *AB* (by prob. 8. sect. 4.) the lower line of the angle, and from the point where it cuts the other line in *C*, let fall a perpendicular *BC* (by prob. 7. sect 4.) and the triangle is constructed: the measures of *AC* and *AB*, from the same scale that *BC* was taken, will answer the question.

What has been said in the two foregoing cases, is sufficient to render the operations in this, both by calculation, Gunter's scale, and Natural sines, so obvious, that it is needless to insert them; however, for the sake of the learner, we give for

Answers; *AC* 264. 5, and *AB* 202. 6.

CASE IV.

The base and hypothenuse given; to find the angles and perpendicular.

Pl. 5. fig. 7.

In the triangle *ABC*, there is given, *AB* 300 and *AC* 500: the angles *A* and *C*, and the perpendicular *BC*, are required.

1st. *By Construction.*

From a scale of equal parts lay 300 from *A* to *B*; on *B* erect an indefinite blank perpendicular line, with *AC* 500, from the same scale, and one foot of the compass, in *A*, cross the perpendicular line in C; and the triangle is constructed.

By prob. 17. sect. 4. measure the angle *A*, and let *BC* be measured from the same scale of equal parts that *AC* and *AB* were taken from; and the answers are obtained.

2d. *By Calculation.*

1. *Making AC the radius.*

AC : *R* : : *AB* : *S.C.*
R : *AC* : : *S.A.* : *BC.*

That is, as AC	=	500	2.698970
is to radius,	=	90°	10.000000
So is AB	=	300	2.477121
			12.477121
to the sine of C, =36° 52′			9.778151

By cor. 2. theo. 5. 90°—36° 52′ = 53° 08′ the angle A.

As radius	=	90°	10.000000
is to AC,	=	500	2.698970
So is the sine of A	=	53° 08′	9.903108
to BC,	=	400	2.602078

2. *Making AB the radius.*

$AB : R :: AC :$ sec. A.
$R. : AB :: T.A : BC$.

That is, as AB	=	300	2.477121
is to radius	=	90°	10.000000
So is AC	=	500	2.698970
			12.698970
to the secant of A, =53°. 08′			10.221849

As radius	=	90°	10.000000
is to AB,	=	300	2.477121
So is the tangent of A=53°. 08′			10.124990
to BC,	=	400	2.602111

Or BC may be found from cor. 2. theo. 14. sect. 4.

3d. By Gunter's Scale.

1. Making AC the radius.

Extend from 500 to 300, on the line of numbers; that extent will reach from 90°, on the line of sines, to 36°. 52′ for the angle C.

Again, extend from 90° to 53°. 08′, on the line of sines, that extent will reach from 500 to 400, on the line of numbers, for BC.

2. Making AC the radius, the second stating is thus performed.

Extend from radius, or the tangent of 45°, to 53°. 08′, that extent will reach from 300 to 400, for BC.

4th. Solution by Natural Sines.

$$\frac{R\times AB.}{AC} = S \text{ of } C; \text{ and } \frac{AC\times S \text{ of } A.}{R} = BC.$$

Thus, AC AB
5,00) 300.0000,00

.600000=Nat. sine 36° 52′.

and,

Nat. sine of A = 53° 8′ = .800034
AC = 500

400.017000=BC.

CASE V.

The perpendicular and hypothenuse given, to find the angles and base.

Pl. 5. fig. 8.

In the triangle ABC there is BC 306, and AC 370 given; to find the angles A and C; and the base AB.

1*st.* *By Construction.*

Draw a blank line from any point, in which, at B, erect a perpendicular, on which lay BC 306, from a scale of equal parts: from the same scale, with AC 370, in the compasses, cross the first drawn blank line in A, and the triangle ABC is constructed.

Measure the angle A (by prob. 17. sect. 4.); and also AB, from the same scale of equal parts the other sides were taken from, and the answers are now found.

The operations by calculation, the square root, Gunter's scale, and Natural sines, are here omitted, as they have been heretofore fully explained: the statings, or proportions, must also be obvious, from what has already been said.

Answers; The angle A 55° 48′; therefore the angle C 34° 12′, and AB 208.

CASE VI.

The base and perpendicular given; to find the angles and hypothenuse.

Pl. 5. fig. 9.

In the triangle *ABC*, there is *AB* 225, and *BC* 272, given; to find the angles *A* and *C*, and the hypothenuse *AC*.

1*st. By Construction,*

Draw a blank line, on which lay *AB* 225, from a scale of equal parts; at *B*, erect a perpendicular; on which lay *BC*, 272, from the same scale: join *A* and *C*, and the triangle is constructed.

As before, let the angle *A*, and the hypothenuse *AC* be measured; in order to find the answers.

2*d. By Calculation.*

1. *Making AB the radius.*

AB : *R* : : *BC* : *T. A.*
R. : *AB* : : sec. *A* : *AC.*

2. *Making BC the radius.*

BC : *R* : : *AB* : *T. C.*
R. : *BC* : : Sec. *C* : *AC.*

By calculation; the answers from the foregoing proportions are easily obtained, as before.

But because *AC*, by either of the said proportions is found by means of a secant; and since there is no line of secants on Gunter's scale; after

having found the angles as before, let us suppose *AC* the radius, and then

$$1.\ S.A : BC :: R. : AC.$$
$$\text{or } 2.\ S.C : AB :: R : AC.$$

These proportions may be easily resolved, either by calculation, or Gunter's scale, as before; and thus the hypothenuse *AC* may be found without a secant.

From the two given sides, the hypothenuse may be easily obtained, from cor. 1. theo. 14. sect. 4.

Thus the square of *AB* = 50625
Add the square of *BC* = 73984

```
124609 (353 = AC
9
-----
65)346
   325
-----
703)2109
    2109
    ----
```

From what has been said on logarithms, it is plain,

1. That half the logarithm of the sum of the squares of the two sides, will be the logarithm of the hypothenuse. Thus,

The sum of squares, as before, is 124609; its log. is 5.095549, the half of which is 2.547774.;

and the corresponding number to this, in the tables, will be 353, for AC.

2. And that half of the logarithm of the difference of the squares of AC and AB, or of AC and BC, will be the logarithm of BC, or of AB.

The following examples are inserted for the exercise of the learner.

1. Given,	the angle C 64° 40′ AC 3876	AB BC	required.
2. Given,	the angle C 47° 20′ AB 17	AC BC	required.
3. Given,	the angle C 28° 30′ BC 27187	AB AC	required.
4. Given,	AB 2 AC 3	the angles and BC	required.
5. Given,	BC 17 AC 21.6	the angles and AB	required.
6. Given,	AB 2871.64 BC 3176.2	the angles and AC	required.

The answers are omitted, that the learner may resolve them for himself by the foregoing methods; by which means he will find and see more distinctly their mutual agreements: and become more expert, and better acquainted with the subject.

OBLIQUE ANGLED

PLANE TRIGONOMETRY.

BEFORE we proceed to the solution of the four cases of Oblique angled triangles, it is necessary to premise the following theorems.

THEO. I.

Pl. 5. fig. 10.

In any plane triangle ABC, the sides are proportional to the sines of their opposite angles; that is, S. C : AB : : S. A : BC, and S. C : AB : : S. B : AC; also S. B : AC : : S. A : BC.

By theo. 10. sect. 4. the half of each side is the sine of its opposite angle; but the sines of those angles, in tabular parts, are proportional to the sines of the same in any other measure; and therefore the sines of the angles will be as the halves of their opposite sides; and since the halves are as the wholes, it follows, that the sines of their angles are as their opposite sides; that is, *S. C : AB : : S. A : BC, &c. Q. E. D.*

THEO. II.

Fig. 11.

In any plane triangle ABC, the sum of the two given sides AB and BC, including a given angle ABC, is to their difference, as the tangent of half the sum of the two unknown angles A and C is to the tangent of half their difference.

Produce *AB*, and make *HB* = *BC*, and join *HC*: let fall the perpendicular *BE*, and that will bisect

the angle HBC (by theo. 9. sect. 4.) through B draw BD parallel to AC, and make $HF=DC$, and join BF; take $BI=BA$, and draw IG parallel to BD or AC.

It is then plain that AH will be the sum, and HI the difference of the sides AB and BC: and since $HB=BC$, and BE perpendicular to HC, therefore $HE=EC$ (by theo. 8. sect. 4.); and since $BA=BI$, and BD and IG parallel to AC, therefore $GD=DC=FH$, and consequently $HG=FD$, and $\frac{1}{2}HG=\frac{1}{2}FD$ or ED. Again, EBC being half HBC, will be also half the sum of the angles A and C (by theo. 4. sect. 4.) also, since HB, HF, and the included angle H, are severally equal to BC, CD, and the included angle BCD: therefore (by theo. 6. sect. 4.) $HBF=DBC=BCA$ (by part 2. theo. 3. sect. 4.) and since $HBD=A$ (by part. 3. theo. 3. sect. 4.) and $HBF=BCA$: therefore BFD is the difference, and EBD, half the difference of the angles A and C: then making BE the radius, it is plain, that EC will be the tangent of half the sum, and ED the tangent of half the difference of the two unknown angles A and C: now IG being parallel to AC; $AH : IH :: CH : GH$. (by cor. 1. theo. 20. sect. 4.) But the wholes are as their halves, that is, $AH : IH :: CE : ED$, that is as the sum of the two sides AB and BC, is to their difference; so is the tangent of half the sum of the two unknown angles A and C, to the tangent of half their difference. *Q. E. D.*

THEO. III.

Fig. 12.

In any right lined plane triangle ABD; the base AD will be to the sum of the other sides, AB, BD, as the difference of those sides is to the difference of the segments of the base, made by the perpendicular BE; viz. the difference between AE and ED.

Produce BD, till $BG=AB$ the lesser leg; and on B as a centre, with the distance BG or BA, describe a circle $AGHF$; which will cut BD, and AD in the points H and F; then it is plain, that GD will be the sum, and HD the difference of the sides AB and BD; also since $AE=EF$ (by theo. 8. sect. 4.) therefore, FD is the difference of AE ED, the segments of the base; but (by theo. 17. sect. 4.) $AD : GD :: HD : FD$; that is, the base is to the sum of the other sides, as the difference of those sides is to the difference of the segments of the base. *Q. E. D.*

THEO. IV.

Fig. 13.

If to half the sum of two quantities, be added half their difference; the sum will be the greatest of them; and if from half the sum be subtracted half their difference; the remainder will be the least of them.

Let the two quantities be represented by AB and BC: (making one continued line;) whereof AB is the greatest, and BC the least; bisect the whole line AC in E; and make $AD=BC$; then

it is plain, that AC is the sum, and DB the difference of the two quantities; and AE or EC, their half sum, and DE or EB their half difference. Now if to AE we add EB, we shall have AB the greatest quantity; and if from EC we take EB, we shall have BC the least quantity. *Q. E. D.*

Cor. Hence, if from the greatest of two quantities, we take half the difference of them, the remainder will be half their sum; or if to half their difference be added the least quantity, their sum will be half the sum of the two quantities.

OBLIQUE ANGLED TRIANGLES.

CASE I.

TWO sides, and an angle opposite to one of them given; to find the other angles and side.

Pl. 5. fig. 11.

In the triangle ABC, there is given AB 240, the angle A 46° 30′, and BC 200; to find the angle C, being acute, the angle B, and the side AC.

1*st. By Construction.*

Draw a blank line, on which set AB 240, from a scale of equal parts; at the point A, of the line AB, make an angle of 46° 30′, by an indefinite blank line; with BC 200, from a like scale of equal parts that AB was taken, and one foot in B, describe the arc DC to cut the last blank line in the points D and C. Now if the angle C had been required obtuse, lines from D to B, and to A, would constitute the triangle; but as it is required acute,

draw the lines from C to B and to A, and the triangle ABC is constructed. From a line of chords let the angles B and C be measured; and AC from the same scale of equal parts that AB and BC were taken; and you will have the answers required.

2d. By Calculation.

This is performed by theo. 1. of this sect. thus;

As BC	=	200	2.301030
is to the sine of A	=	46°. 30′	9.860562
So is AB	=	240	2.380211
			12.240773
to the sine of C,	=	60°. 31′	9.939743

180°—the sum of the angles A and C, will give the angle B, by cor. 1. theo. 5. sect. 4.

A 46°. 30′
C 60. 31

180°—107°. 1′=72°. 59′=B.

As the sine of A	=	46°. 30′	9.860562
is to BC,	=	200	2.301030
So is the sine of B	=	72°.59′	9.980555
			12.281585
to AC,	=	263. 7	2.421023

3d. By Gunter's Scale.

Extend from 200 to 240, on the line of numbers; that distance will reach from 46° 30′ on the line of sines, to 60° 31′ for the angle C.

Extend from $46° 30'$, to $72° 59'$, on the line of sines; that distance will reach from 200 to 263.7 on the line of numbers, for *AC*.

NOTE. The method by Natural Sines will be obvious from the foregoing analogies.

CASE II.

Two angles and a side given; to find the other sides.

PL. 5. *fig.* 15.

In the triangle ABC, there is the angle A $46° 30'$ *AB* 230; *and the angle B* $37° 30'$, *given to find AC and BC.*

1st. *By Construction.*

Draw a blank line, upon which set *AB* 230, from a scale of equal parts; at the point *A* of the line *AB*, make an angle of $46° 30'$, by a blank line; and at the point *B* of the line *AB* make an angle of $37° 30'$, by another blank line: the intersection of those lines gives the point *C*, then the triangle *ABC* is constructed. Measure *AC* and *BC* from the same scale of equal parts that *AB* was taken; and you have the answer required.

2d. *By Calculation.*

By (cor. 1. theo. 5. sect. 4.) $180°$—the sum of the angles A and $B=C$.

A $46° 30'$
B $37. 30$

$180° - 84°. 00' = 96° 00' = C$.

By def. 27. sect. 4. The sine of 96°=the sine of 84°, which is the supplement thereof; therefore instead of the sine of 96°, look in the tables for the sine of 84°.

By theo. 1. of this sect.

As the sine of C	=	96° 00′	9.997614
is to AB,	=	230	2.361728
So is the sine of A	=	46° 30′	9.860562
			12.222290
to BC,	=	167.8	2.224676

As the sine of C	=	96° 00′	9.997614
is to AB,	=	230	2.361728
So is the sine of B	=	37° 30′	9.784447
			12.146175
to AC,	=	140.8	2.148561

3d. *By Gunter's Scale.*

Extend from 84° (which is the supplement of 96°) to 46° 30′ on the sines; that distance will reach from 230 to 168, on the line of numbers, for BC.

Extend from 84° to 37°. 30′, on the sines; that extent will reach from 230 to 141, on the line of numbers, for AC.

CASE III.

Two sides and a contained angle given; to find the other angles and side.

Pl. 5. *fig.* 16.

In the triangle ABC, there is AB 240, the angle A 36° 40′ and AC 180, given; to find the angles C and B, and the side BC.

1st. *By Construction.*

Draw a blank line, on which from a scale of equal parts, lay AB 240; at the point A of the line AB, make an angle of 36° 40′, by a blank line; on which from A, lay AC 180, from the same scale of equal parts; measure the angles C and B, and the side BC, as before; and you have the answers required.

2d. *By Calculation.*

By cor. 1. theo. 5. sect. 4. 180° — the angle A 36°. 40′ = 143°. 20′ the sum of the angles C and B: therefore half of 143°. 20′, will be half the sum of the two required angles, C and B.

By theo. 2. of this sect.

As the sum of the two sides AB and AC = 420
is to their difference, = 60

So is the tangent of half the sum of the two unknown angles C and B } = 71° 40′
to the tangent of half their difference = 23° 20′

By theo. 4.

To half the sum of the angles C and $B = 71° 40'$
Add half their difference as now found $= 23\ 20$.

The sum is the greatest angle, or ang. $C = 95\ 00$

Subtract, and you have the least angle, or $B = 48\ 20$

The angle C and B being found; BC is had, as before, by theo. 1. of this sect. Thus,

$$S.\ B : AC :: S : A : BC.$$
$$48° 20' : 180 :: 36° 40 : 143.\ 9.$$

3d. By Gunter's Scale.

Because the two first terms are of the same kind, extend from 420 to 60 on the line of numbers; lay that extent from 45° on the line of tangents, and keeping the left leg of your compasses fixed, move the right leg to 71°. 40'; that distance laid from 45° on the same line will reach to 23°. 30', the half difference of the required angles. Whence the angles are obtained, as before.

The second proportion may be easily extended, from what has been already said.

CASE IV.

PL. 5. fig. 17.

The three sides given, to find the angles.

In the triangle ABC, there is given, AB 64, *AC* 47, *BC* 34: *the angles A, B, C, are required.*

1st. By Construction.

The construction of this triangle must be manifest, from prob. 1. sect. 4.

2d. By Calculation.

From the point *C*, let fall the perpendicular *CD* on the base *AB*; and it will divide the triangle into two right angled ones, *ADC* and *CBD*; as well as the base *AB*, into the two segments, *AD* and *DB*.

AC	47
BC	34
Sum	81
Difference	13

By theo. 3. of this sect.

As the base or the longest side, *AB*	64
is to the sum of the other sides, *AC* and *BC*,	81
So is the difference of those sides	13
to the difference of the segments of the base *AD DB*.	16.46

By theo. 4. of this sect.

To half the base, or to half the sum of the segments *AD* and *DB*.	32
Add half their difference, now found,	8.23
Their sum will be the greatest segment *AD*	40.23

Subtract, and their difference will be the least segment DB, } 23.77

In the right angled triangle ADC, there is AC 47, and AD 40. 23, given, to find the angle A.

This is resolved by case 4. of right angled plane trigonometry, thus,

$AD : R : : AC :$ Sec. A
40. 23 : 90° : : 47 : 31° 08′

Or it may be had by finding the angle ACD, the complement of the angle A; without a secant, thus,

$AC : R : : AD : S. ACD.$
47 : 90° : : 40 23 : 58° 52′

90 — 58° 52′ = 31°. 08′, the angle A.

Then by theo. 1. of this sect.

$BC : S. A : : AC : S. B.$
34 : 31° 08′ : : 47 : 45° 37.

By cor. 1. theo. 5. sect. 4. 180° — the sum of A and $B = C$.

A 31°. 08′
B 45. 37

180°—76. 45 = 103°. 15′, the angle C.

3d. *By Gunter's Scale.*

The first proportion is extended on the line of numbers; and it is no matter whether you extend from the first to the third, or to the second term, since they are all of the same kind: If you extend to the second, that distance applied to the third, will give the fourth; but if you extend from the first to the third, that extent will reach from the second to the fourth.

The methods of extending the other proportions have been already fully treated of.

An example in each case of oblique angled triangles.

$$1.\ \text{Given, } \left\{\begin{array}{ll} AC & 290 \\ C & 69^\circ.30' \\ AB & 350 \end{array}\right\} \begin{array}{l} A \\ B \\ BC \end{array} \text{ required.}$$

$$2.\ \text{Given, } \left\{\begin{array}{ll} C & 24^\circ.20' \\ B & 128^\circ.30 \\ AC & 3246 \end{array}\right\} \begin{array}{l} AB \\ \\ BC \end{array} \text{ required.}$$

$$3.\ \text{Given, } \left\{\begin{array}{ll} AC & 6 \\ C & 124^\circ.30' \\ BC & 4.5 \end{array}\right\} \begin{array}{l} A \\ B \\ AB \end{array} \text{ required.}$$

$$4.\ \text{Given, } \left\{\begin{array}{ll} AB & 46 \\ AC & 92 \\ BC & 52 \end{array}\right\} \begin{array}{l} A \\ B \\ C \end{array} \text{ required.}$$

Additional Exercises with their Answers.

QUESTIONS FOR EXERCISE.

1. Given the Hypothenuse 108 and the Angle opposite the Perpendicular 25° 36; required the Base and Perpendicular.

Answer. The Base is 97.4, and the Perpendicular 46.66.

2. Given the Base 96 and its opposite Angle 71° 45′; required the Perpendicular and the Hypothenuse.

Answer. The Perpendicular is 31.66 and the Hypothenuse 101.1.

3. Given the Perpendicular 360 and its opposite Angle 58° 20′; required the Base and the Hypothenuse.

Answer. The Base is 222, and the Hypothenuse 423.

4. Given the Base 720 and the Hypothenuse 980; required the Angles and the Perpendicular.

Answer. The Angles are 47° 17′. and 42° 43′, and the Perpendicular 664.8

5. Given the Perpendicular 110.3 and the Hypothenuse 176.5; required the Angles and the Base.

Answer. The Angles are 38° 41′ and 51° 19′, and the Base 137.8.

6. Given the Base 360 and the Perpendicular 480; required the Angles and the Hypothenuse.

Answer. The Angles are 53° 8′ and 36° 52′, and the Hypothenuse 600.

7. Given one Side 129, an adjacent Angle 56° 30, and the opposite Angle 81° 36′ : required the third Angle and the remaining Sides.

Answer. The third Angle is 41° 54′, and the remaining Sides are 108.7 and 87.08.

8. Given one Side 96.5, another Side 59.7, and the Angle opposite the latter Side 31° 30′ : required the remaining Angles and the third Side.

Answer. This Question is ambiguous; the given Side opposite the given Angle being less than the other given Side (see Rule I. ;) hence, if the Angle opposite the Side 96.5 be acute, it will be 57° 38′, the remaining Angle 90° 52′, and the third Side 114.2 ; but if the Angle opposite the Side 96.5 be obtuse, it will be 122° 22′, the remaining Angle 26° 8′, and the third Side 50.32.

9. Given one Side 110, another Side 102, and the contained Angle 113° 36′ : required the remaining Angles and the third Side.

Answer. The remaining Angles are 34° 37′ and 31° 47′, and the third Side is 177.5.

10. Given the three Sides respectively, 120.6, 125.5, and 146.7 : required the Angles.

Answer. The Angles are 51° 53′, 54° 58′, and 73° 9′.

The student, who has advanced thus far in this work with diligence and active curiosity, is now prepared to study, with ease and pleasure, the following part; which comprehends all the necessary directions for the practice of Surveying.

PART II,

Or the Practical Surveyor's Guide.

SECT. I.

Containing a particular Description of the several Instruments used in Surveying, with their respective Uses.

THE CHAIN.

THE stationary distance, or merings of ground, are measured either by Gunter's chain of four poles or perches, which consists of 100 links; (and this is the most natural division) or by one of 50 links, which contains two poles or perches: but because the length of a perch differs in many places, therefore the length of chains and their respective links will differ also.

The *English statute-perch* is 5½ yards, the two-pole chain is 11 yards, and the four-pole one is 22 yards; hence the length of a link in a statute-chain is 7.92 inches.

There are other perches used in different parts of England, as the perch of *woodland measure*, which is 6 yards; that of *church-land measure*, which is 7 yards, and the *forest measure perch*, which is 8 yards.

For the more ready reckoning the links of a four-pole chain, there is a large ring, or sometimes a round piece of brass, fixed at every 10 links; and at 50 links, or in the middle, there are two large rings. In such chains as have a brass piece at every 10 links, there is the figure 1 on the first piece, 2 on the second, 3 on third, *&c.* to 9. By leading therefore that end of the chain forward which has the least number next to it, he who carries the hinder end may easily determine any number of links: thus, if he has the brass piece number 8, next to him, and six links more in a distance, that distance is 86 links. After the same manner 10 may be counted for every large ring of a chain which has not brass pieces on it; and the number of links is thus readily determined.

The two-pole chain has a large ring at every 10 links, and in its middle, or at 25 links, there are 2 large rings; so that any number of links may be the more readily counted off, as before.

The surveyer should be careful to have his chain measured before he proceeds on business, for the rings are apt to open by frequently using it, and its length is thereby increased, so that no one can be too circumspect in this point.

In measuring a stationary distance, there is an object fixed in the extreme point of the line to be measured; this is a direction for the hinder chainman to govern the foremost one by, in order that the distance may be measured in a right line; for if the hinder chainman causes the other to cover the object, it is plain the foremost is then in a right line towards it. For this reason it is necessary to have a person that can be relied on, at the hinder

end of the chain, in order to keep the foremost man in a right line; and a surveyor who has no such person, should chain himself. The inaccuracies of most surveys arise from bad chaining, that is, from straying out of the right line, as well as from other omissions of the hinder chainman: no person, therefore, should be admitted at the hinder end of the chain, of whose abilities in this respect, the surveyor was not previously convinced; since the success of the survey, in a great measure, depends on his care and skill.

In setting out to measure any stationary distance, the foreman of the chain carries with him 10 iron pegs pointed, each about ten inches long; and when he has stretched the chain to its full length, he at the extremity thereof sticks one of those pegs perpendicularly in the ground; and leaving it there, he draws on the chain till the hinder man checks him when he arrives at that peg: the chain being again stretched, the fore man sticks down another peg, and the hind man takes up the former; and thus they proceed at every chain's length contained in the line to be measured, counting the surplus links contained between the last peg, and the object at the termination of the line, as before: so that, the number of pegs taken up by the hinder chainman, expresses the number of chains; to which, if the odd links be annexed, the distance line required in chains and links is obtained, which must be registered in the field book, as will hereafter be shewn.

If the distance exceeds 10, 20, 30, *&c.* chains, when the leader's pegs are all exhausted, the hinder chainman, at the extremity of the 10 chains, delivers him all the pegs; from whence they pro-

ceed to measure as before, till the leader's pegs are again exhausted, and the hinder chainman at the extremity of these 10 chains again delivers him the pegs; from whence they proceed to measure the whole distance line in the like manner; then it is plain, that the number of pegs the hinder chainman has, being added to 10, if he had delivered all the pegs once to the leader, or to 20 if twice, or to 30 if thrice, *&c.* will give the number of chains in that distance; to which if the surplus links be added, the length of the stationary distance is known in chains and links.

It is customary, and indeed necessary, to have red, or other coloured cloth, fixed to the top of each peg, that the hinder man at the chain may the more readily find them; otherwise, in chaining through corn, high grass, briars, rushes, *&c.* it would be extremely difficult to find the pegs which the leader puts down: by this means no time is lost, which otherwise must be, if no cloths are fixed to the pegs, as before.

It will be necessary here to observe, that all slant, or inclined surfaces, as sides of hills, are measured horizontally, and not on the plane or surface of the hill, and is thus effected.

Pl. 8. fig. 4.

Let *ABC* be a hill, the hindmost chainman is to hold the end of the chain perpendicularly over the point *A* (which he can the better effect with a plummet and line, than by letting a stone drop, which is most usual) as *d* is over A, while the leader puts down his peg at *e*: the eye can direct the horizontal position near enough, but if greater accuracy

were required, a quadrant applied to the chain, would settle that. In the same manner the rest may be chained up and down; but in going down, it is plain the leader of the chain must hold up the end thereof, and the plummet thence suspended, will mark the point where he is to stick his peg. The figure is sufficient to render the whole evident; and to shew that the sum of the chains will be the horizontal measure of the base of the hill; for $de=Ao, fg=op, hi=pq,$ &c. therefore $de \times fg \times hi,$ &c. $= Ao \times op \times pq,$ &c. $= AC$, the base of the hill. If a whole chain cannot be carried horizontally, half a chain, or less, may, and the sum of these half chains, or links, will give the base, as before.

If the inclined side of the hill be the plane surface, the angle of the hill's inclination may be taken, and the slant height may be measured on the surface; and thence (by case 1. of right-angled trigonometry) the horizontal line answering to the top, may be found; and if we have the angle of inclination given on the other side, with those already given; we can find the horizontal distance across the hill, by case 2. of oblique trigonometry.

All inclined surfaces are considered as horizontal ones; for all trees which grow upon any inclined surface, do not grow perpendicular thereto, but to the plane of the horizon: thus if Ad, ef, gh, &c. were trees on the side of a hill, they grow perpendicular to the horizontal base AC, and not to the surface AB: hence the base will be capable to contain as many trees as are on the surface of the hill, which is manifest from the continuation of them thereto. And this is the reason that the area of the base of a hill, is considered to be equal in value to the hill itself.

Besides, the irregularities of the surfaces of hills in general are such, that they would be found impossible to be determined by the most able mathematicians. Certain regular curve surfaces have been investigated with no small pains, by the most eminent; therefore an attempt to determine in general the infinity of irregular surfaces which offer themselves to our view, to any degree of certainty, would be idle and ridiculous, and for this reason also, the horizontal area is only attempted.

Again, if the circumjacent lands of a hill be planned or mapped, it is evident we shall have a plan of the hill's base in the middle: but were it possible to put the hill's surface in lieu thereof, it would extend itself into the circumjacent lands, and render the whole an heap of confusion: so that if the surfaces of hills could be determined, no more than the base could be mapped

Roads are usually measured by a wheel for that purpose, called the Perambulator, to which there is fixed a machine, at the end whereof there is a spring, which is struck by a peg in the wheel, once in every rotation; by this means the number of rotations is known; if such a wheel were 3 feet 4 inches in diameter, one rotation would be 10½ feet, which is half a plantation perch; and because 320 perches make a mile, therefore 640 rotations will be a mile also; and the machinery is so contrived, that by means of a hand, which is carried round by the work, it points out the miles, quarters, and perches, or sometimes the miles, furlongs, and perches.

Or roads may be measured by a chain more accurately; for 80 four-pole, 160 two-pole chains, or 320 perches, make a mile as before: and if roads

are measured by a statute-chain, it will give you the miles English, but if by a plantation chain, the miles will be Irish. Hence an English mile contains 1760, and an Irish mile 2240 yards; and because 14 half yards is an Irish, and 11 half yards is an English perch, therefore 11 Irish perches, or Irish miles, are equal to 14 English ones.

Since some surveys are taken by a four-pole, and others by a two-pole chain; and as ground for houses is measured by feet, we will shew how to reduce one to the other, in the following problems.

PROB. I.

To reduce two-pole chains and links to four-pole ones.

If the number of chains be even, the half of them will be the four-pole ones, to which annex the given links, thus,

Ch. *L.*
1. In 16. 37 of two-pole chains, how many four-pole ones?

Ch. *L.*
Answer 8. 37.

But if the number of chains be odd, take the half of them for chains, and add 50 to the links, and they will be four-pole chains and links, thus,

Ch. *L.*
2. In 17. 42 of two-pole chains, how many four-pole ones?

Ch. *L.*
Answer 8. 92.

PROB. II.

To reduce four-pole chains and links, to two-pole ones.

Double the chains, to which annex the links, if they be less than 50; but if they exceed 50, double the chains, add one to them, and take 50 from the links, and the remainder will be the links, thus,

	Ch.	L.	
1. In	8.	37	of four-pole chains, how many
	2.		two-pole ones?
	16.	37	

	Ch.	L.	
2. In	8.	82	of four-pole chains, how many
	2.	50	two-pole ones?
	17.	32	Answer.

PROB. III.

To reduce four-pole chains and links, to perches and decimals of a perch.

The links of a four-pole chain are decimal parts of it, each link before the hundreth part of a chain; therefore if the chain and links be multiplied by 4, (for 4 perches are a chain) the product will be the perches and decimal parts of a perch. Thus,

	Ch.	L.	
How many perches in	13.	64	of four-pole chains,
		4	
Answer	54.	56	perches.

PROB. IV.

To reduce two-pole chains and links, to perches and decimals of a perch.

They may be reduced to four-pole ones (by prob. 1.) and thence to perches and decimals (by the last,) or,

If the links be multiplied by 4, carrying one to the chains, when the links are, or exceed 25; and the chains by 2, adding one, if occasion be; the product will be perches, and decimals of a perch. Thus,

	Ch.	*L.*	
1. In	17.	21	of two-pole chains, how many
	2.	4	perches.
Answer,	34.	84	perches.

	Ch.	*L.*	
2. In	15.	38	of two-pole chains, how mnay
	2.	4	perches.
Answer,	31.	52	perches.

PROB. V.

To reduce perches, and decimals of a perch, to four-pole chains and links.

Divide by 4, so as to have two decimal places in the quotient, and that will be four-pole chains and links. Thus,

In 31. 52 perches, how many four-pole chains and links?

Ch. L.
4)31.52(7. 88 Answer.

35

32

PROB. VI.

To reduce perches and decimals of a perch, to two-pole chains and links.

The perches may be reduced to four-pole chains (by the last) and from thence to two-pole chains (by prob. 2.) or,

Divide the whole number by 2, the quotient will be chains; to the remainder annex the given decimals, and divide by 4, the last quotient will be the links. Thus,

In 31.52 perches, how many two-pole chains and links?

Ch. L.
2)31.52(15. 38 Answer.

11

4)152(38

32

PROB. VII.

To reduce chains and links, to feet and decimal parts of a foot.

If they be two-pole chains, reduce them to four-pole ones: (by prob. 1.) these being multiplied by the feet in a four-pole chain, will give the feet and decimals of a foot. Thus,

Ch. *L.*
In 17. 21 of two-pole chains, how many feet?

Ch. *L.*
8. 71 of four-pole chains.
66 feet = 1 chain.

5226.
5226

Feet 574.86
12

Inches 10.32
4

1.28

Answer 574 Feet 10¼ Inches.

PROB. VIII.

To reduce feet and inches to chains and links.

Reduce the inches to the decimal of a foot, and annex that to the feet; that divided by the feet in a four-pole chain, will give the four-pole chains and

links in the quotient: these may be reduced to two-pole chains and links, if required, by prob. 2. Thus,

Feet. Inches.
In 217. 9 how many two-pole chains?
12)9.00.(75 the decimal of 9 inches.

60

66)217.75(3. 29 of four-pole chains, or

197

Ch. L.
655 6. 29

61

How to take a Survey by the CHAIN *only.*

PROB. I.

To survey a piece of ground, by going round it, and the method of taking the angles of the field, by the chain only.

Pl. 6. fig. 6.

Let *ABCDEFG* be a piece of ground to be surveyed: beginning at the point *A*, let one chain be laid in a direct line from *A*, towards *G*, where let a peg be left, as at *c*; and again, the like distance from *A* in a direct line towards *B*; where another peg is also to be left, as at *d*: let the distance from *d* to *c* be measured, and placed in the field-book, in

the second column under the denomination of angles, in a line with station No. 1; and in the same line, under the title of distances, in the third column, let the measure of the line *AB* in chains and links be inserted. Being now arrived at *B*, let one chain be laid in a direct line from *B* towards *A*, where let a peg be left, as at *f*, and again, the like distance from *B* in a direct line towards *C*, where let also another peg be left, as at *e*; the distance from *e* to *f* is to be inserted in the field-book in the second column, under angles, in a line with station No. 2; and in the same line, under the title of distances in the third column, let the measure of the line *BC*, in chains and links, be inserted: after the same manner we may proceed from *C* to *D*, and thence to *E*; but because the angle at *E*, *viz. FED*, is an external angle, after having laid one chain from *E* to *h*, and to *g*, the distance from *g* to *h* is measured, and inserted in the column of angles, in a line with station No. 5. and on the side of the field-book against that station, we make an asterisk, thus *, or any other mark, to signify that to be an external angle, or one measured out of the ground. Proceed we then as before, from *E* to *F*, to *G*, and thence to *A*, measuring the angles and distances, and placing them as before, in the field-book, opposite to their respective stations; so will the field-book be completed in manner following.

N. B. After this manner the angles for inaccessible distances may be taken, and the method of constructing or laying them down, as well as the construction of the map, from the following field-notes, must be obvious from the method of taking them.

The form of the field-book, with the title.

A field-book of part of the land of Grange, in the parish of Portmarnock, barony of Coolock, and county of Dublin; being part of the estate of L. P. Esq. let to C. D. farmer. Surveyed January 30, 1782.

Taken by a four-pole chain.

Remarks.	No. Sta.	Angles Ch. L.	Distan. Ch. L.
Mr. J. D's part of Grange	1	1.80	17.65
	2	1.79	18.50
Mr. L. P's part of Portmar-	3	1.76	28.00
nock strand	4	1.41½	20.00
*	5	1.87¼	14.83
Widow J. G's part of Grange	6	1.14	19.41
	7	1.89	24.53

Close at the first station.

Explanation of the remarks.

Mr. J. D's part of Grange bounds, or is adjacent to the surveyed land from the first to the third station; Mr. L. P's part of Portmarnock bounds it from the third to the fourth station; the strand then is the boundary from thence to the sixth, and from the sixth to the first station, the widow J. G's part of Grange is the boundary.

It is absolutely necessary to insert the persons' names, and town-lands, strands, rivers, bogs, rivulets, *&c.* which bound or circumscribe the land which is surveyed, for these must be expressed in the map.

In a survey of a town-land, or estate, it is sufficient to mention only the circumjacent town-lands,

without the occupiers' names: but when a part only of a town-land is surveyed, then it is necessary to insert the person or persons' names, who hold any particular parcel or parcels, of such town-land, as bound the parts surveyed.

When an angle is very obtuse, as most in our present figure are, *viz.* the angles at *A*, *B*, *C*, *E*, and *G*: it will be best to lay a chain from the angular point, as at *A*, on each of the containing sides to *c* and to *d*; and any where nearly in the middle of the angle, as at *e*: measuring the distances *ce* and *ed*; and these may be placed for the angle in the field-book. Thus,

No.	Sta.	Angle.	
		Ch. L.	*Ch. L.*
		1.03 } 1.09 }	17.65

For when an angle is very obtuse, the chord line, as *ed*, will be nearly equal to the radii *Ac* and *Ad*; so if the arc *ced* be swept, and the chord line *ed* be laid on it, it will be difficult to determine exactly that point in the arc where *ed* cuts it: but if the angle be taken in two parts, as *ce*, the arc, and the angle thence, may be truly determined and constructed.

After the same manner any piece of ground may be surveyed by a two-pole chain.

PROB. II.

To take a survey of a piece of ground from any point within it, from whence all the angles can be seen; by the chain only.

Pl. 6. fig. 6.

Let a mark be fixed at any point in the ground, as at *H*, from whence all the angles can be seen; let the measures of the lines *HA*, *HB*, *HC*, *&c.* be taken to every angle of the field from the point *H*; and let those be placed opposite to No. 1, 2, 3, 4, *&c.* in the second column of the radii: the measures of the respective lines of the mearing, *viz.* *AB*, *BC*, *CD*, *DE*, *&c.* being placed in the third column of distances, will complete the field-book. Thus,

Remarks.	No.	Radii. Ch. L.	Distan. Ch. L.
	1	20.00	17.65
	2	21.72	18.50
	3	21.74	28.00
	4	25.34	20.00
	5	17.20	14.83
	6	29.62	19.41
	7	21.20	24.53

Close at the first station.

If any line of the field be inaccessible, as suppose *CD* to be, then by way of proof that the distance *CD* is true, let the measure of the angle *CHD* be taken by the line *oo*, with the chain: if this angle corresponds with its containing sides, the length of the line *DC* is truly obtained, and the whole work is truly taken.

Note, That in setting off an angle, it is necessary to use the largest scale of equal parts, *viz.* that of the inch, which is diagonally divided into 100 parts, in order that the angle should be accurately laid down; or if two inches were thus divided for angles, it would be the more exact; for it is by no means necessary that the angles should be laid from the said scale with the stationary distances.

PROB. III.

To take a survey by the chain only, when all the angles cannot be seen from one point within.

Pl. 6. fig. 7.

Let the ground to be surveyed be represented by 1, 2, 3, 4, *&c.* Since all the angles cannot be seen from one point, let us assume 3 points, as *A*, *B*, *C*, from whence they may be seen; at each of which let a mark be put, and the respective sides of the triangle be measured and set down in the field-book; let the distance from *A* to 1, and from *B* to 1, be measured, and these will determine the point 1; let the other lines which flow from *A*, *B*, *C*, as well as the circuit of the ground, be then measured as the figure directs; and thence the map may be easily constructed.

There are other methods which may be used; as dividing the ground into triangles, and measuring the 3 sides of each; or by measuring the base and perpendicular of each triangle. But this we shall speak of hereafter.

PROB. IV.

How to take any inaccessible distance by the chain only.

Pl. 8. *fig.* 8.

Suppose *AB* to be the breadth of a river, or any other inaccessible distance, which may be required.

Let a staff or any other object be set at *B*, draw yourself backward to any convenient distance *C*, so that *B* may cover *A* : from *B*, lay off any other distance by the river's side to *E*, and complete the parallelogram *EBCD* : stand at *D*, and cause a mark to be set at *F*, in the direction of *A* ; measure the distance in links from *E* to *F*, and *FB* will be also given. Wherefore *EF* : *ED* : : *FB* : *AB*. Since it is plain (from part 1. theo. 3. sect. 4. and theo. 2. sect. 4.) the triangles *EFDBFA* are mutually equiangular.

If part of the chain be drawn from *B* to *C*, and the other part from *B* to *E* ; and if the ends at *E* and *C* be kept fast, it will be easy to turn the chain over to *D*, so as to complete a parallelogram ; by reckoning off the same number of links you had in *BC*, from *E* to *D*, and pulling each part straight.

THE

CIRCUMFERENTOR.

THIS instrument is composed of a brass circular box, about five or six inches in diameter; within which is a brass ring, divided on the top into 360 degrees, and numbered 10, 20, 30, *&c.* to 360: in the centre of the box is fixed a steel pin finely pointed, called a centre-pin, on which is placed a needle touched by a loadstone, which always retains the same situation; that is, it always points to the North and South points of the horizon nearly, when the instrument is horizontal, and the needle at rest.

The box is covered with a glass lid, in a brass rim, to prevent the needle being disturbed by wind or rain, at the time of surveying: there is also a brass lid or cover, which is laid over the former to preserve the glass in carrying the instrument.

This box is fixed by screws, to a brass index, or ruler, of about 14 or 15 inches in length, to the ends whereof are fixed brass sights, which are screwed to the index, and stand perpendicular thereto: in each sight is a large and a small aperture, or slit, one over the other; but these are changed, that is, if the large aperture be uppermost in the one sight, it will be lowest in the other, and

so of the small ones: therefore the small aperture in one is opposite to the large one in the other; in the middle of which last, there is placed a horse hair, or fine silk thread.

The instrument is then fixed on a ball and socket; by the help of which and a screw, you can readily fix it horizontally in any given direction; the socket being fixed on the head of a three-legged staff, whose legs, when extended, support the instrument whilst it is used.

To take field notes by the Circumferentor.

Pl. 6. fig. 6.

Let your instrument be fixed at any angle as *A*, your first station; and let a person stand at the next angle *B*, or cause a staff, with a white sheet, to be set there perpendicularly for an object to take your view to: then having placed your instrument horizontally (which is easily done by turning the box so that the ends of the needle may be equidistant from its bottom, and it traverses or plays freely) turn the flower-de-luce, or north part of the box, to your eye, and looking through the small aperture, turn the index about, till you cut the person or object in the next angle *B*, with the horse hair, or thread of the opposite sight; the degrees then cut by the south end of the needle, will give the number to be placed in the second column of your field-book in a line with station No. 1, and expresses the number of degrees the stationary line is from the north, counting quite round with the sun.

Most needles are pointed at the south end, and have a small ring at the north: such needles are

better than those which are pointed at each end, because the surveyor cannot mistake by counting to a wrong end; which error may be frequently committed, in using a two-pointed needle.

Two-pointed needles have sometimes a ring, but more usually a cross towards the north end: and the south end is generally bearded towards its extremity, and sometimes not, but its arm is a naked right line from the cap at the centre.

Having taken the degrees or bearing of the first stationary line *AB*, let the line be measured, and the length thereof in chains and links be inserted in the third column of your field-book, under the title of distances, opposite to station No. 1.

It is customary, and even necessary, to cause a sod to be dug up at each station, or place where you fix the instrument: to the end, that if any error should arise in the field-book, it may be the more readily adjusted and corrected, by trying over the former bearings and stationary distances.

Having done with your first station, set the instrument over the hole or spot where your object stood, as at *B*, for your second station, and send him forward to the next angle of the field, as at *C*; and having placed the instrument in an horizontal direction, with the sights directed to the object at *C*, and the north of the box next your eye, count your degrees to the south end of the needle, which register in your field-book, in the second column opposite to station No. 2; then measure the stationary distance *BC*, which insert in the third column, and thus proceed from angle to angle, sending your object before you, till you

return to the place where you began, and you will have the field-book complete; observing always to signify the parties names who hold the contiguous lands, and the names of the town-lands, rivers, roads, swamps, lakes, &c. that bound the land you survey, as before; and this is the manner of taking field-notes by what is called fore-sights.

But the generality of mearsmen frequently set themselves in disadvantageous places, so as often to occasion two or more stations to be made, where one may do, which creates much trouble and loss of time; we will therefore shew how this may be remedied, by taking back-sights, thus: let your object stand at the point where you begin your survey, as at *A*; leaving him there, proceed to your next angle *B*, where fix your instrument so, that you may have the longest view possible towards *C*. Having set the instrument in an horizontal position, turn the south part of the box next your eye, and having cut your object at *A*, reckon the degrees to the south point of the needle, which will be the same as if they were taken from the object to the instrument, the direction of the index being the same. Let the degree be inserted in the field-book, and the stationary distance be measured and annexed thereto, in its proper column; and thus proceed from station to station, leaving your object in the last point you left, till you return to the first station *A*.

By this method your stations are laid out to the best advantage, and two men may do the business of three, for one of those who chain, may be your object; but in fore-sights, you must have an object before you, besides two chainmen.

It was said before, that a surveyor should have a person with him to carry the hinder end of the chain, on whom he can depend: this person should be expert and ready at taking off-sets, as well as exact in giving a faithful return of the length of every stationary line. One who has such a person, and who uses back-sights, will be able to go over near double the ground he could at the same time, by taking fore-sights, because of overseeing the chaining; for should he take back-sights, he must be obliged, after taking his degree, to go back to the foregoing station, to oversee the chaining, and by this means to walk three times over every line, which is a labour not to be borne.

Or a back and a fore-sight may be taken at one station, thus; with the south of the box to your eye, observe from *B* the object *A*, and set down the degree in your field-book, cut by the south end of the needle. Again from *B* observe an object at *C*, with the north of the box to your eye, and set down the degree cut by the south point of the needle, so have you the bearings of the lines *AB* and *BC*; you may then set up your instrument at *D*, from whence take a back-sight to *C*, and a fore-sight to *E*: thus the bearings may be taken quite round, and the stationary distances being annexed to them, will complete the field-book.

But in this last method, care must be taken to see that the sights have not the least cast on either side; if they have, it will destroy all: and yet with the same sights you may take a survey by fore-sights, or by back-sights only, with as great truth as if the sights were ever so erect, provided the same cast continues without any alteration; but, upon the whole, back-sights only will be found the readiest method.

If your needle be pointed at each end, in taking fore-sights, you may turn the north part of the box to your eye, and count your degrees to the south part of the needle, as before; or you may turn the south of the box to your eye, and count your degrees to the north end of the needle.

But in back-sights you may turn the north of the box to your eye, and count your degrees to the north point of the needle; or you may turn the south of the box to your eye, and count your degrees to the south end of the needle.

The brass ring in the box is divided on the side into 360 degrees, thus; from the north to the east into 90, from the north to the west into 90, from the south to the east into 90, and from the south to the west into 90 degrees; so the degrees are numbered from the north to the east or west, and from the south to the east or west.

The manner of using this part of the instrument is this; having directed your sights to the object, whether fore or back, as before, observe the two cardinal points of your compass, the point of the needle lies between, (the north, south, east and west being called the four cardinal points, and are graved on the bottom of the box) putting down those points, together by their initial letters, and thereto annexing the number of degrees, counting from the north or south, as before, thus; if the point of your needle lies between the north and east, north and west, south and east, or south and west points in the bottom of the box, then put down *NE*, *NW*, *SE*, or *SW*, annexing thereto the number of degrees cut by the needle on the side of the ring, counting from the north or south as before.

But if the needle point exactly to the north, south, east, or west, you are then to write down *N*, *S*, *E*, or *W*, without annexing any degree.

This is the manner of taking field notes, whereby the content of ground may be universally determined by calculation; and they are said to be taken by the quartered compass, or by the four nineties.

To find the number of degrees contained in any given angle.

Set up your instrument at the angular point, and thence direct the sights along each leg of the angle, and note down their respective bearings, as before; the difference of these bearings, if less than 180, will be the quantity of degrees contained in the given angle; but if more, take it from 360, and the remainder will be the degrees contained in the given angle.

THE

THEODOLITE.

THIS instrument is a circle, commonly of brass, of ten or twelve inches in diameter, whose limb is divided into 360 degrees, and those again are subdivided into smaller parts, as the magnitude of it will admit; sometimes by equal divisions, and sometimes by diagonals, drawn from one concentric circle of the limb to another.

In the middle is fixed a circumferentor, with a needle; but this is of little or no use, except in finding a meridian line, or the proper situation of the land.

Over the brass circle is a pair of sights, fixed to a moveable index, which turns on the centre of the instrument, and upon which the circumferentor-box is placed.

This instrument will either give the angles of the field, or the bearing of every stationary distance line, from the meridian; as the circumferentor and quartered compass do.

To take the angles of the field.

PL. 6. *fig*. 6.

Lay the ends of your index to 360°, and 180°; turn the whole about with the 360 from you; direct

the sights from A to G, and screw the instrument fast; direct them from A, to cut the object at B; the degree then cut by that end of the index which is opposite you, will be the quantity of the angle GAB, to place in your field-book; to which annex the measure of the line AB, in chains and links; set up your instrument at B, unscrew it, and lay the ends of your index to 360 and 180; turn the whole about with the 360 from you, or 180 next you, till you cut the object at A; screw the instrument fast, and direct your sights to the object at C; and the degree then cut by that end of the index which is opposite to you, will be the quantity of the angle ABC. Thus proceed from station to station, still laying the index to 360, turning it from you, and observing the object at the foregoing station, screwing the instrument fast, and observing the object at the following station, and counting the degrees to the opposite end of the index, will give you the quantity of each respective angle.

LEMMA.

All the angles of any polygon, are equal to twice as many right angles as there sides less by four. Thus, all the angles A, B, C, D, E, F, G, are equal to twice as many right angles as there are sides in the figure, less by four.

Pl. 6. *fig.* 6.

Let the polygon be disposed into triangles, by lines drawn from any assigned point H within it, as by the lines HA, HB, HC, &c. It is evident then (by theo. 2. sect. 4. part 1.) that the three angles of each triangle are equal to two right; and consequently, that the angles in all the triangles are twice as many right ones as there are sides:

but all the angles about the point *H*, are equal to four right (by cor. 2. theo. 1. sect. 4.); therefore the remaining angles are equal to twice as many right ones as there are sides in the figure, abating four. *Q. E. D.*

SCHOLIUM.

Hence we may know if the angles of a survey be truly taken; for if their sum be equal to twice as many right angles, as there are stations, abating four right angles, you may conclude that the angles were truly taken, otherwise not.

If you take the bearing of any line with the circumferentor, that bearing will be the number of degrees the line is from the north; consequently the north must be a like number of degrees from the line, and thus the north, and of course the south, as well as the east and west, or the situation of the land, is obtained.

To take the bearing of each respective line from the meridian; or to perform the office of the circumferentor, or quartered compass by the theodolite.

Set your instrument at the first station, and lay the index to 360° and 180°, with the flower-de-luce of the box next 360; unscrew the instrument, and turn the whole about, till the north and south points of the needle cut the north and south points in the box; then screw it fast, and the instrument is north and south, if there be no variation in the needle; but if there be, and its quantity known, it may be easily allowed.

The circumferentor-box may then be taken off.

Direct the sights to the object at the second station, and the degree cut by the opposite end of the index will be the bearing of that line from the north, and the same that the circumferentor would give.

After having measured the stationary distance, set up your instrument at the second station; unscrew it, and set either end of the index to the degree of the last line, and turning the whole about with that degree towards you, direct your sights to an object at the foregoing station, and screw the instrument fast; it will then be parallel to its former situation, and consequently north and south; direct then your sights to an object at the following station, and the degree cut by the opposite end of the index, will be the bearing of that line.

In like manner you may proceed through the whole.

If the brass circle be divided into four nineties, from 360 and 180, and the letters *N*, *S*, *E*, *W*, be applied to them; the bearings may be obtained by putting down the letters the far or opposite end of the index lies between, and annexing thereto the degrees from the *N.* or *S;* and this is the same as the quartered compass.

If you keep the compass box on, to see the mutual agreement of the two instruments; after having fixed the theodolite north and south, as before; turn the index about with the north end or flower-de-luce next your eye, and count the degree to the opposite, or south end of the index, and this will correspond with the degree cut by the south end of the needle.

At the second, or next station, unscrew the instrument, and set the south of the index to the degree of the last station; turn the whole about, with the south of the index to you, and cut the object at the foregoing station; screw the instrument fast, and with the north of the index to you, cut the object at the next following station, the degree then cut by the south of the index, will correspond with the degree cut by the south end of the needle, and so through the whole.

Some theodolites have a standing pair of sights fixed at 360 and 180, besides those on the moveable index; if you would use both, look through the standing sights, with the 180 next you, to an object at the foregoing station: screw the instrument fast, and direct the upper sights on the moveable index, to the object at the following station, and the degree cut by the opposite end of the index, will give you the quantity of the angle of the field.

Two pair of sights can be of no use in finding the angles from the meridian; and inasmuch as one pair is sufficient to find the angles of the field, the second can be of no use: besides, they obstruct the free motion of the moveable index, and therefore are rather an incumbrance than of any real use. Some will have it, that they are useful with the others, for setting off a right angle, in taking an off-set: and surely this is as easily performed by the one pair on the moveable index: thus, if you lay the index to 360 and 180, and cut the object either in the last or following station, screw the instrument fast, and turn the index to 90 and 270, and then it will be at right angles with the line. So that the small sights, at those of the circle, can be

of no additional use to the instrument, and therefore should be laid aside as useless.

This instrument may be used in windy and rainy weather, as well as in mountainous and hilly grounds; for it does not require an horizontal position to find the bearing, or angle, as the needle doth; and therefore is preferred to any instrument that is governed by the needle.

THE SEMICIRCLE.

THIS instrument, as its name imports, is a half circle, divided from its diameter into 180 degrees, and from thence again, that is, from 0, to 360 degrees: it is generally made of brass, and is from 8 to 18 inches diameter.

On the centre there is a moveable index with sights, on which is placed a circumferentor-box, as in the theodolite.

This instrument may be used as the theodolite in all respects; but with this difference, when you are to reckon the degree to that end of the index which is off the semicircle, you may find it at the other end, reckoning the degree from 180 forwards,

THE

PLANE TABLE.

A PLANE TABLE is an oblong of oak, or other wood, about 15 inches long, and 12 broad; they are generally composed of 3 boards, which are easily taken asunder, or put together, for the convenience of carriage.

There is a box frame, with 6 joints in it, to take off and put on as occasion serves; it keeps the table together, and is likewise of use to keep down a sheet of paper which is put thereon.

The outside of the frame is divided into inches and tenths, which serve for ruling parallels or squares on the paper, or for shifting it, when occasion serves.

The inside of the frame is divided into 360 degrees, which, though unequal on it, yet are the degrees of a circle produced from its centre, or centre of the table, where there is a small hole.

The degrees are subdivided as small as their distance will admit; at every tenth degree are two numbers, one the number of degrees, the other its complement to 360.

There is another centre hole about $\frac{1}{4}$ of the table's breadth from one edge, and is in the mid-

dle between the two ends. To this centre hole on the other side of the frame, there are the divisions of a semicircle, or 180 degrees; and these again are subdivided into halves, or quarters, as the size of the instrument will admit.

That side of the frame on which the 360 degrees are, supplies the place of a theodolite, the other, that of a semicircle.

There is a circumferentor-box of wood, with a paper chart at the bottom, applied to one side of the table by a dove-tail joint, fastened by a screw. This box (besides its rendering the plane table capable of answering the end of a circumferentor) is very useful for placing the instrument in the same position every remove.

There is a brass ruler or index, of about two inches broad, with a sharp or fiducial edge, at each end of which is a sight; on the ruler are scales of equal parts, with and without diagonals, and a scale of chords; the whole is fixed on a ball and socket, and set on a three-legged staff.

To take the angles of a field by the table.

Having placed the instrument at the first station, turn it about till the north end of the needle be over the meridian, or flower-de-luce of the box, and there screw it fast. Assign any convenient point, to which apply the edge of the index, so as through the sights you may see the object in the last station, and by the edge of the index from the point draw a line. Again, turn about the index with its edge to the same point, and through the sights ob-

serve the object in the second station, and from the point, by the edge of the index, draw another line; so is the angle laid down; on that last line set off the distance to the second station, in chains and links; apply your instrument to the second station, taking the angle as before; and after the like manner proceed till the whole is finished.

This method may be used in good weather, if the needle be well touched and play freely; but if it be in windy weather, or the needle out of order, it is better, after having taken the first angle as before, and having removed your instrument to the second station, and placed the needle over the meridian line as before, to lay the index on the last drawn line, and look backward through the sights; if you then see the object in the first station, the table is fixed right, and the needle is true; if not, turn the table about, the index lying on the last line, till through the sights you see the object in the first station: and then screw it fast, and keeping the edge of the index to the second station, direct your sights to the next; draw a line by the edge of the index, and lay off the next line; and proceed through the whole without using the needle, as you do with the theodolite.

If the sheet of paper on the table be not large enough to contain the map of the ground you survey, you must put on a clean sheet, when the other is full; and this is called shifting of paper, and is thus performed.

Pl. 6. fig. 8.

Let *ABCD* represent the sheet of paper on the plane table, upon which the plot *E, F, G, H, I,*

K, L, M, is to be drawn; let the first station be *E*; proceed as before from thence to *F*, and to *G*; then proceeding to *H*, you find there is not room on your paper for the line *GH*; however draw as much of the line *GH*, as the paper can hold, or draw it to the paper's edge. Move your instrument back to the first station *E*, and proceed the contrary way to *M*, and to *L*; but in going from thence to *K*, you again find your sheet will not hold it; however, draw as much of the line *LK* on the sheet as it can hold.

Take that sheet off the table, first observing the distance *oo* of the lines *GH* and *LK*, by the edge of the table; take off that sheet, and mark it with No. 1, to signify it to be the first taken off. Having then put on another sheet, lay that distance *oo* on the contrary end of the table, and so proceed as before, with the residue of the survey, from *o* to *H*, to *K*, and thence to *o*; so is your survey complete.

In the like manner you may proceed to take off, and put on, as many sheets as are convenient; and these may afterwards be joined together with mouth glue, or fine white wafer, very thin.

If the index be fixed to the first centre, using the 360 side, it will then serve as a theodolite, and when to the second centre, using the 180 side, it will serve as a semicircle; by either of which you may survey in rainy weather, when you cannot have paper on the table.

To measure Angles of Altitude by the Circumferentor, Theodolite, Semicircle, or Plane Table.

1. *To take an angle of altitude, by the circumferentor.*

LET the glass lid be taken off, and let the instrument be turned on one side, with the stem of the ball into the notch of the socket, so that the circle may be perpendicular to the plane of the horizon; let the instrument be placed in this situation before the object, so that the top thereof may be seen through the sights; let a plummet be suspended from the centre pin, and the object being then observed, the complement of the number of degrees, comprehended between the thread of the plummet, and that part of the instrument which is next your eye, will give the angle of altitude required.

2. If an angle of altitude is to be taken by the theodolite, or semicircle, let a thread be run through a hole at the centre, and a plummet be suspended by it; turn the instrument on one side, by the help of the ball and notch in the socket for that purpose, so that the thread may cut 90, having 360 degrees next you; screw it fast in that position, and through the sights cut the top of the objects; and the degrees then cut by the end of the index next you, are the degrees of elevation required. An angle of depression is taken the contrary way.

3. By the plane table an angle of altitude is taken in the like manner, by suspending a plummet from the centre thereof, having turned the table on one side, and fixed the index to the centre by a screw, so as to move freely, let the thread cut 90, look through the sights as before, and you have the angle of elevation, and on the contrary that of depression.

THE

PROTRACTOR.

THE protractor is a semicircle annexed to a scale, and is made of brass, ivory, or horn; its diameter is generally about five or six inches.

The semicircle contains three concentric semicircles at such distances from each other, that the spaces between them may contain figures.

The outward circle is numbered from the right to the left hand, with 10, 20, 30, *&c.* to 180 degrees; the middlemost the same way, from 180 to 360 degrees; and the innermost from the upper edge of the scale both ways, from 10, 20, 30, *&c.* to 90 degrees.

It is easy to conceive that the protractor, though a semicircle, may be made to supply the place of a whole circle; for if a line be drawn, and the centre-hole of the protractor be laid on any point in that line, the upper edge of the scale corresponding with that line, the divisions on the edge of the semicircle will run from 0 to 180, from right to left: again, if it be turned the other way, or downwards, keeping the centre-hole thereof on the aforesaid point in the line, then the divisions will run from

180 to 360, and so completes an entire circle with the former semicircle.

The use of the protractor is to lay off angles, and to delineate or draw a map, or plan of any ground from the field notes; and is performed in the following manner.

To protract a field-book, when the angles are taken from the meridian.

Pl. 6. *fig.* 9.

On your paper rule lines parallel to each other, at an inch asunder (being most usual), or at any other convenient distance; on the left end of the parallels put *N.* for north, and on the right *S.* for south; put *E.* at the top for east, and *W.* at the bottom of your paper for west.

Then let the following field-book be that which is to be protracted, the bearings being taken from the meridian, whether by a circumferentor, theodolite, or semicircle, and measured with a two-pole chain.

No.	Bearing.	Ch. L.
1	283½	55.20
2	348¼	12.36
3	317	29.20
4	266	55.20
5	193	40.00
6	124	76.00
7	63¼	87.02

Close at the first station.

Pitch upon any convenient point on your paper for your first station, as at 1, on which lay the centre-hole of your protractor, with a protracting pin; then if the degrees be less than 180, turn the arc of your protractor downwards, or towards the west; but if more than 180, upwards, or towards the east.

Or if the right hand be made the north, and the left the south, the west will be then up, and the east down.

In this case, if the degree be less than 180, turn the arc of your protractor upwards, or towards the west; and if more, downwards, or towards the east.

By the foregoing field-book, the first bearing is 283½, turn the arc of your protractor upwards, keeping the pin in the centre-hole, move the protractor so that the parallel lines may cut opposite divisions, either on the ends of the scale, or on the degrees, and then it is parallel. This must be always first done, before you lay off your degrees.

Then by the edge of the semicircle, keeping the protractor steady, with the pin prick the first bearing 283½, and from the centre point, through that point or prick, draw a blank line with the pin, on which from a scale of equal parts, or from the scale's edge of the protractor, lay off the distance 55*C.* 20*L.* so is that station protracted.

At the end of the first station, or at 2, which is the beginning of the second, with the pin place the centre of the protractor, turning the arc up, because the bearing of the second station is more

than 180, *viz.* 348¼. Place your protractor parallel as before, and by the edge of the semicircle, with the pin prick at that degree, through which and the end of the foregoing station, draw a blank line, and on it set the distance of that station.

In the like manner proceed through the whole, only observe to turn the arc of your protractor down, when the degrees are less than 180.

If you lay off the stationary distances by the edge of the protractor, it is necessary to observe, that if your map is to be laid down by a scale of 40 perches to an inch, every division on the protractor's edge will be one two-pole chain; ½ a division will be 25 links, and ¼ of a division will be 12½ links.

If your map is to be laid down by a scale of 20 perches to an inch, two divisions will be one two-pole chain; one division will be 25 links; ½ a division 12½ links, and ¼ of a division will be 6¼ links.

In general, if 25 links be multiplied by the number of perches to an inch, the map is to be laid down by, and the product be divided by 20 (or which is the same thing, if you cut off one and take the half), you will have the value of one division on the protractor's edge, in links and parts.

EXAMPLES.

1. How many links in a division, if a map be laid down by a scale of 8 perches to an inch?

25
8
———
2|0)20|0
———
10 links. Answer.
———

2. How many links in a division, if a map be laid down by a scale of 10 perches to an inch?

25
10
———
2|0)25|0
———
12.5 or 12½ links. Answer.
———

And so of any other.

To protract a field-book, taken by the angles of the field.

NOTE. We here suppose the land surveyed is kept on the right hand as you survey.

Draw a blank line with a ruler of a length greater than the diameter of the protractor; pitch upon any convenient point therein, to which apply the centre-hole of your protractor with your pin, turning the arc upwards if the angle be less than 180, and downwards if more; and observe to keep the upper edge of the scale, or 180 and 0 degrees upon the line: then prick off the number of degrees contained in the given angle, and draw a line from the first point through the point at the degrees; upon which lay the stationary distance. Let this line be lengthened forwards and backwards, keeping your first station to the right, and second to the left;

and lay the centre of your protractor over the second station, with your pin, turning the arc upwards, if the angle be less than 180, and downwards, if more; and keeping the 180 and 0 degrees on the line, prick off the number of degrees contained in the given angle, and through that point and the last station draw a line, on which lay the stationary distance; and in like manner proceed through the whole.

In all protractions, if the end of the last station falls exactly in the point you began at, the field-work and protraction are truly taken, and performed; if not, an error must have been committed in one of them: in such case make a second protraction; if this agrees with the former, and neither meet nor close, the fault is in the field-work, and not in the protraction; and then a re-survey must be taken.

REMARKS.

The accuracy of geometrical and trigonometrical mensuration, depends in a great degree on the exactness and perfection of the instruments made use of; if these are defective in construction, or difficult in use, the surveyor will either be subject to error, or embarrassed with continual obstacles. If the adjustments, by which they are to be rendered fit for observation, be troublesome and inconvenient, they will be taken upon trust, and the instrument will be used without examination, and thus subject the surveyor to errors, that he can neither account for, nor correct.

In the present state of science, it may be laid down as a maxim, that every instrument should be

so contrived, that the observer may easily examine and rectify the principal parts; for however careful the instrument-maker may be, however perfect the execution thereof, it is not possible that any instrument should long remain accurately fixed in the position in which it came out of the maker's hand, and therefore the principal parts should be moveable, to be rectified occasionally by the observer.

AN ENUMERATION OF INSTRUMENTS USEFUL TO A SURVEYOR;

Fewer or more of which will be wanted, according to the extent of his work, and the accuracy required.

A case of good pocket instruments.
A pair of beam compasses.
A set of feather-edged plotting scales.
Three or four parallel rules.
A pair of proportional compasses.
A pair of triangular ditto.
A pantagraph.
A cross staff.
A circumferentor.
An Hadley's sextant.
An artificial horizon.
A theodolite.
A surveying compass.
Measuring chains, and measuring tapes.
King's surveying quadrant.
A perambulator, or measuring wheel.
A spirit level with telescope.
Station staves, used with the level
A protracter, with or without a nonius.

To be added for county and marine surveying;

An astronomical quadrant, or circular instrument.

A good refracting and reflecting telescope.
A copying glass.

For marine surveying ;

A station pointer.
An azimuth compass.
One or two boat compasses.

Besides these, a number of measuring rods, iron pins, or arrows, &c. will be found very convenient, and two or three offset staves, which are straight pieces of wood, six feet seven inches long, and about an inch and a quarter square; they should be accurately divided into ten equal parts, each of which will be equal to one link. These are used for measuring offsets, and to examine and adjust the chain.

Five or six staves of about five feet in length, and one inch and an half in diameter, the upper part painted white, the lower end shod with iron, to be struck into the ground as marks.

Twenty or more iron arrows, ten of which are always wanted to use with the chain, to count the number of links, and preserve the direction of the chain, so that the distance measured may be *really* in a straight line.

The pocket measuring tapes, in leather boxes, are often very convenient and useful. They are made to the different lengths of one, two, three, four poles, or sixty-six feet and 100 feet; divided, on one side, into feet and inches, and on the other into links of the chain. Instead of the latter, are sometimes placed the centesimals of a yard, or three feet into 100 equal parts.

SECTION II.

MENSURATION

OF HEIGHTS AND DISTANCES.

1st. Of Heights.

Pl. 5. fig. 18.

THE instrument of least expence for taking heights, is a quadrant, divided into ninety equal parts or degrees; and those may be subdivided into halves, quarters, or eighths, according to the radius, or size of the instrument: its construction will be evident by the scheme thereof.

From the centre of the quadrant let a plummet be suspended by a horse hair: or a fine silk thread of such a length that it may vibrate freely, near the edge of its arc: by looking along the edge *AC*, to the top of the object whose height is required; and holding it perpendicular, so that the plummet may neither swing from it, nor lie on it; the degree then cut by the hair, or thread, will be the angle of altitude required.

If the quadrant be fixed upon a ball and socket on the three-legged staff, and if the stem from the ball be turned into the notch of the socket, so as to bring the instrument into a perpendicular position, the angle of altitude by this means, can be acquired with much greater certainty.

An angle of altitude may be also taken by any of the instruments used in surveying; as has been

particularly shown in treating of their description and uses.

Most quadrants have a pair of sights fixed on the edge *AC*, with small circular holes in them; which are useful in taking the sun's altitude, requisite to be known in many astronomical cases; this is effected by letting the sun's ray, which passes through the upper sight, fall upon the hole in the lower one; and the degree then cut by the thread, will be the angle of the sun's altitude; but those sights are useless for our present purpose, for looking along the quadrant's edge to the top of the object will be sufficient, as before.

PROB. I.

Pl. 5. fig. 19.

To find the height of a perpendicular object at one station, which is on an horizontal plane.

A steeple.

Given, { The angle of altitude, 53 degrees.
Distance from the observer to the foot of the steeple, or the base, 85 feet.
Height of the instrument, or of the observer, 5 feet.

Required, the height of the steeple.

The figure is constructed and wrought, in all respects, as case 2. of right-angled trigonometry; only there must be a line drawn parallel to, and beneath *AB* of 5 feet for the observer's height, to represent the plane upon which the object stands;

to which the perpendicular must be continued, and that will be the height of the object.

Thus, *AB* is the base, *A* the angle of altitude, *BC* the height of the steeple from the instrument, or from the observer's eye, if he were at the foot of it; *DC* the height of the steeple above the horizontal surface.

Various statings for *BC*, as in case 2. of right-angled plane trigonometry.

$$\begin{array}{l} 90^\circ \\ 53=A. \\ \hline 37=C. \\ \hline \end{array}$$

1. *S. C* : *AB* : : *S. A* : *BC*.
   37° 85 53° 112.8.

2. *R.* : *AB* : : *T. A* : *BC*.
   90° 85 53° 112.8.

3. *T. C* : *AB* : : *R.* : *BC*.
   37° 85 90° 112.8

To *BC*	112.8	
Add *DB*	5.	the height of the observer.

Their sum is 117. 8 or 118 feet, the height of the steeple required.

PROB. II.

PL. 5. fig. 20.

To find the height of a perpendicular object, on an horizontal plane; by having the length of the shadow given.

Provide a rod, or staff, whose length is given, let that be set perpendicular, by the help of a quadrant, thus; apply the side of the quadrant AC, to the rod, or staff; and when the thread cuts 90°. it is then perpendicular; the same may be done by a carpenter's or mason's plumb.

Having thus set the rod or staff perpendicular; measure the length of its shadow, when the sun shines, as well as the length of the shadow of the object, whose height is required; and you have the proper requisites given. Thus,

ab, the length of the shadow of the staff, 15 feet.

bc, the length of the staff, 10 feet.

AB, the length of the shadow of the steeple, or object, 135 feet.

Required BC, the height of the object.

The triangles abc, ABC, are similar, thus; the angle $b=B$, being both right; the lines ac, AC are parallel, being rays, or a ray of the sun; whence the angle $a=A$ (by part 3. theo. 3. sect. 4.) and consequently $c=C$. The triangles being therefore mutually equiangular, are similar (by theo. 16. sect. 4) it will be,

ab : *bc* : : *AB* : *BC*.
15 10 135 90. the steeple's height, required.

The foregoing method is most to be depended on; however, this is mentioned for variety's sake.

PROB. III.

Pl. 5. fig. 21.

To take the altitude of a perpendicular object, at the foot of a hill, from the hill's side.

Turn the centre *A* of the quadrant, next your eye, and look along the side *AC*, or 90 side, to the top and bottom of the object; and noting down the angles, measure the distance from the place of observation to the foot of the object. Thus,

Given, { Angle to the foot of the object, $55^{\circ}\frac{1}{4}$ or $55^{\circ}. 15'$
Angle to the top of it, $31^{\circ}\frac{1}{4}$ or $31^{\circ}. 15'$
Distance to the foot of it, 250 feet.

Required, the height of the object.

By Construction.

Draw an indefinite blank line *AD*, at any point in which *A* make the angles *EAB* of $55^{\circ}. 15'$, and *EAC* of $31^{\circ}. 15'$; lay 250 from *A* to *B*; from *B*, draw the perpendicular *BE* (by prob. 7 of geometry (crossing *AC* in *C*; so will *BC* be the height of the object required.

In the triangle *ABC* there is given,

ABE the complement of *EAB* to 90°, which is 34°. 45′.

CAB the difference of the given angle 24°.00′.

The side *AB*, 250. Required, *BC*.

This is performed as case 2. of oblique angular trigonometry. Thus,

180 — the sum of *ABE* 34°. 45′, and *CAB* 24°. 00′ = *ACB* 121°. 15′. Then,

S. ACB : *AB* : : *S. CAB* : *BC*.
121°. 15′ 250 24°. 00′ 119, the height required.

PROB. IV.

Pl. 5. fig. 22.

To take the altitude of a perpendicular object, on the top of a hill, at one station; when the top and bottom of it can be seen from the foot of the hill.

As in prob. I. take an angle to the top, and another to the bottom of the object; and measure from the place of observation to the foot of the object, and you have all the given requisites. Thus,

A Tower on a hill.

Given, { Angle to the bottom, 48°. 36′.
Angle to the top, 67°. 00′.
Dist. to the foot of the object, 136 feet.
Required, the height of the object.

By Construction.

Make the angle $DAB = 48° 30'$, and lay 136 feet from A to B; from B, let fall the perpendicular BD; and that will be the height of the hill; produce BD upwards by a blank line: again, at A, make the angle $DAC = 67° 00'$ by a blank line, and from C where that crosses the perpendicular produced, draw the line CB, and that will be the height of the object required.

Let AC be drawn.

In the triangle ABC, there is given,

The angle ACD the complement of $DAC = 23°. 00'$.

CAB the difference between the two given angles $= 18°. 30'$.

And the side AB 136. To find BC.

$$S\,C :: AB :: S.CAB : BC.$$
$$23° \quad 136 \quad 18°.30' \; 110\tfrac{1}{4}.$$

If BD were wanted, it is easily obtained, by the first case of right-angled plane trigonometry.

PROB. V.

PL. 5. fig. 23.

To take an inaccessible perpendicular altitude, on a horizontal plane.

This is done at two stations, thus:

Let *DC* be a tower which cannot be approached by means of a moat or ditch, nearer than *B*; at *B*, take an angle of altitude, to *C*: measure any convenient distance backward to *A*, which note down; at *A*, take another angle to *C*; so have you the given requisites, thus:

Given, { First angle, 55°. 00′.
Stationary distance, 87 feet.
Second angle, 37°. 00′.

The height of the tower *CD*, is required.

By Construction.

Upon an indefinite blank line, lay off the stationary distance 87, from *A* to *B*; from *B*, set off your first; and from *A*, your second angle; from *C*, the point of intersection of the lines which form these angles, let fall the perpendicular *CD*; and that will be the height of the object required.

The external angle *CBD*, of the triangle *ABC*; is equal to the two internal opposite ones, *A*, and *ACB* (by theo. 4. sect. 4.): wherefore if one of the internal opposite angles be taken from the external angle, the remainder will be the other internal opposite one, thus;

$$CBD\ 55° - A\ 37° = ACB\ 18°.$$

Therefore in the triangle *ABC*; we have the angles *A*, and *AGB*, with the side *AB* given to find *BC*.

$$S.\ ACB : AB :: S.\ A : BC.$$
$$18° \quad 87 \quad 37° \quad 169.4$$

Having found *BC*, we have in the triangle *BCD* the angle *CBD* 55°, consequently *BCD* 35°, and *BC* 169.4; to find *DC*.

This is performed by the first case of right-angled trigonometry, three several ways; thus:

1. *R* : *BC* : : *S. CBD* : *DC*.
   90° 169.4 55° 138.8.
   The height required.

2. Sec. *CBD* : *BC* : : *T. CBD* : *DC*.
   55° 169.4 55° 138.8.
   The height required.

3. Sec. *BCD* : *BC* : : *R* : *CD*.
   35° 169.4 90° 138.8.
   The height required.

If *BD*, the breadth of the moat, were required; it may also be found, by three different statings, as in the first case of right-angled plane trigonometry.

PROB. VI.

Pl. 5. fig. 24.

Let *BC*, a may-pole, whose height is 100 feet, be broken at *D*; the upper part of which, *DC*, falls upon an horizontal plane, so that its extremity, *C*, is 34 feet from the bottom or foot of the pole.

Required, the segments *BD* and *DC*.

By Construction.

Lay 34 feet from *A* to *B*; on *B* erect the perpendicular *BC* of 100 feet; and draw *AC*; bisect

AC (by prob. 4. geom.) with the perpendicular line, *EF*; and from *D*, where it cuts the perpendicular *BC*, draw *AD*, which will be the upper segment; and *DB* will be the lower.

By cor. to lemma, preceding theo. 7. geom. $AD=DC$; and (by the lemma) the angle $C=CAD$.

In the triangle *ABC*, find *C* as in case 6, of right-angled trigonometry, thus;

1. $BC : R :: AB : T.\ C=GAD.$
   100 90° 34 18° 47′

By theo. 4. geom. The external angle $ABD=$ 37° 34′, or to twice the angle *C*, i. e. to *C* and *GAD*.

Then in the triangle *ABD*, there is *ABD* 37° 34′, therefore also its complement *DAB* 52° 26′, and *AB* 34, given, to find *AD* and *BD*.

By the second case of right-angled trigonometry.

2. $S.\ ADB : AB :: R : AD$ or *DC*.
   37° 34′ 34 90° 55.77.

$BC-DC=BD.$
100—55.77=44.23 required.

These may be had from other statings, as in the second case aforesaid.

PROB. VII.

Pl. 5. fig. 25.

To take the altitude of a perpendicular object on a hill, from a plane beneath it.

This is done at two stations, thus;

Let the height *DC*, of a wind-mill on a hill be required.

From any part of the plane whence the foot of the object can be seen, let angles be taken to the foot and top; measure thence any convenient distance towards the object, and at the end thereof, take another angle to the top: and you have the proper requisites, thus;

First station. Angle to the foot *DAB* 21° 00′.
Angle to the top *CAB* 35° 00′.
Stationary distance *AB* 104 feet.

Second station. Angle to the top 48° 30.

DC required.

By Construction.

On an indefinite blank line, lay the stationary distance *AB* 104 feet; from *A*, set off the second, and from *B*, the third given angle; and from the intersecting point *C* of the line formed by them, let fall the perpendicular *CE*; from *A* set off the first angle, and the line formed by it will determine the point *D*. Thus have we the height of the hill, as well as that of the wind-mill.

The angle $CBE-A=ACB$, as in the last prob.

In the triangle ABC, find AC thus;

$S.\ ACB : AB :: S.\ ACB$ (or sup. of CBE) $: AC$
$13^{\circ}.\ 30' : 104 :: 131^{\circ}.30' : 333.6$

The angle $CAE-DAE=CAD$.

The angle $ACD=AED\times EAD$, by theo. 4.

In the triangle CAD, find CD thus,

$S.\ ADC : AC :: S.\ CAD : DC$
$111^{\circ}. : 333.6 :: 14 : 86.46$ required.

CE, BE, or DE, may be found by other various statings, as set forth in the first and second cases of right-angled trigonometry.

PROB. VIII.

Pl. 5. fig. 26.

To find the length of an object, that stands obliquely on the top of a hill, from a plane beneath.

Let CD be a tree whose length is required.

This is done at two stations.

Make a station at B, from whence take an angle to the foot, and another to the top of the tree; measure any convenient distance backward to A, from whence also let an angle be taken to the foot, and another to the top; and you have the requisites given. Thus,

First station. Angle to the foot $EBD = 36°.\ 30'$.
Angle to the top $EBC = 44°.\ 30'$.
Stationary distance AB = 104 feet.

Second station. Angle to the foot $EAD = 24°.\ 30'$.
Angle to the top $EAC = 32°.\ 00'$.

Let DC and DE be required.

The geometrical constructions of this and the next problem are omitted; as what has been already said, and the figures, are looked upon as sufficient helps.

$EBC - A = ACB$, or $44°.\ 30' - 32°. = 12°.\ 30'$. as before.

In the triangle ABC, find BC. Thus,

1. $S.\ ACB : AB :: S.\ A : BC.$
   $12°.\ 30'$ 104 $32°$ 254.7.

$EBD - EAD = ADB$, or $36°.\ 30' - 24°.\ 30' = 12°\ 00'$.

In the triangle ADB, find DB, thus;

2. $S.\ ADB : AB :: S.\ DAB : DB.$
   $12°\ 00'$ 104 $24°.\ 30'$. 207.4

$CBE - DBE = CBD$, or $44°.\ 30' - 36°.\ 30' = 8°\ 00'$

In the triangle CBD there is given, CB 254.7, DB 207.4, and the angle CBD $8°\ 00'$; to find DC.

This is performed as case 3. of oblique angled trigonometry, thus;

3. $BC \times BD : BC - BD :: T.$ of $\frac{1}{2} BDC + BCD :$
462.1 47.3 86°. 00′.
$T.$ of $\frac{1}{2} BDC - BCD.$
55°. 40′.
86°. 00′ + 55°. 40′ = 141°. 40′ = BDC.
86°. 00′ − 55°. 40′ = 30°. 20′ = BCD.

4. $S. BCD : BD :: S. CBD : DC.$
30°. 20′ 207.4 8°. 00′ 57.15 length of the tree.

To find DE in the triangle DBE.

Say $R. : BD :: S. DBE : DE,$
90°. 207.4 36°. 30′ 123.4 height of the hill.

PROB. IX.

To find the height of an inaccessible object CD, on a hill BC, from ground that is not horizontal.

Pl. 6. fig. 1.

From any two points, as G and A, whose distance GA, is measured, and therefore given; let the angles HGD, BAD, BAC, and EAG, be taken; because GH is parallel to EA (by part 2. theo. 3. geom.) the angle $HGA = EAG$; therefore $EAG \times HGD = AGD$: and (by cor. 1. theo. 1. geom) 180 — the sum of EAG and $BAD = GAD$; and, (by cor. 1. theo. 5. geom.(180 — the sum of the angles AGD and $GAD = GDA$: thus we have the angles of the triangle AGD, and the side AG given; thence (by case 2. of obl. ang. trig.) AD may be easily found. The angle $DAB - CAB = DAC$, and 90° — $BAD = ADC$; and 180° — the sum of DAC and $ADC = ACD$: so have we the

several angles of the triangle *ACD* given, and the side *AD*; whence (by case 2. of obl. trig.) *CD* may be easily found. We may also find *AC*, which with the angle *BAC*, will give *CB* the height of the hill.

The solutions of the several problems in heights and distances, by Gunter's scale, are omitted; because every particular stating has been already shewn by it, in trigonometry.

2d. OF DISTANCES.

THE principal instruments used in surveying, will give the angles or bearings of lines; which has been particularly shewn, when we treated of them.

PROB. I.

Pl. 6. fig. 2.

Let *A* and *B* be two houses on one side of a river, whose distance asunder is 293 perches: there is a tower at *C* on the other side of the river, that makes an angle at *A*, with the line *AB* of 53° 20′; and another at *B*, with the line *BA* of 66° 20′; required the distance of the tower from each house, *viz.* *AC* and *BC*.

This is performed as case 2. of oblique angled trigonometry, thus;

1. *S. C* : *AB* : : *S. A* : *BC*.
60° 20′ 293 53° 20′ 270.5.

2. *S. C* : *AB* : : *S. B* : *AC*.
60° 20′ 293 66° 20′ 308.8.

PROB. II.

Pl. 6. fig. 11.

Let *B* and *C*, be two houses whose direct distance asunder, *BC*, is inaccessible: however it is

known that a house at A is 252 perches from B, and 230 from C; and that the angle BAC, is found to be 70°. What is the distance BC, between the two houses?

This is performed as case 3. of oblique angled trigonometry, thus;

1. $AB+AC : AB-AC :: T.\text{ of } \frac{1}{2} C+B ;$
$\quad 482 \quad 22 \quad 55°.\ 00'$

$T.\text{ of } \frac{1}{2} C-B$
$3°\ 44'$

$55°+3°.\ 44'=58°.\ 44'=C.\ 55°-3°.\ 44'=51°,\ 16 =B.$

2. $S.\ C : AB :: S.\ A : BC.$
$58°.\ 44' \quad 252 \quad 70° \quad 277.$

PROB. III.

Pl. 6. fig. 3.

Suppose ABC a triangular piece of ground, which by an old survey we find to be thus; AB 260, AC 160, BC 150 perches, the mearing lines AC and BC, are destroyed or plowed down, and the line AB, only remaining. What angles must be set off at A and B, to run new mearings by exactly where the old ones were?

This is performed as in case 4. of oblique angled trigonometry, thus;

1. $AB : AC+BC :: AC-BC : AD-DB.$
$260 \quad 310 \quad 10 \quad 11.92$

$130 + 5.96 = 135.96 = AD.$
$130 - 5.96 = 124.04 = DB.$

2. $AD : R :: AC :$ Sec. $A.$
136 90° :: 160 31°. 47′.

3. $BC : S. A :: AC : S. B.$
150 31°. 47′ 160 34°. 10.

PROB. IV.

Pl. 6. fig. 4.

Let D and C, be two trees in a bog, to which you can have no nearer access than at A and B; there is given, DAB 100°, CAB 36°. 30′, CBA 121°. DBA 49°, and the line AB 113 perches. Required, the distances of the trees DC.

180°—the sum of DBA and $DAB = ADB = 31°$.
180°—the sum of CAB and $CBA = ACB = 22. 30.$

In the triangle ABD, find DB, thus;

1. $S. ADB : AB :: S. DAB : DB.$
31° 113 :: 100° 216.

And in the triangle ABC, find BC, thus;

2. $S. ACB : AB :: S. CAB : BC.$
22° 30′ 113 36° 30′ 175.6.

In the triangle DBC, you have $DBC = ABC - ABD = 72°$; likewise the sides BD, BC, as before found, given to find DC.

3. $BD + BC : BD - BC :: T.$ of $\frac{1}{2}$ $DCB + CDB :$
391.6 40.4 54°

T. of ½ *DCB*—*CDB*.

8° 05′.

54° + 8° 05′ = 62° 05′ = *DCB*,
54° — 8° 05′ = 45° 55′ = *CDB*.

4. *S. CDB* : *BC* : : *S. DBC* : *DC*.
45° 55′ 175.6 72° 232.5.

LEMMA.

Pl. 6. *fig.* 12.

If from a point C, of a triangle ABC, inscribed in a circle, there be a perpendicular CD, let fall upon the opposite side AB; that perpendicular is to one of the sides, including the angle, as the other side, including the angle, is to the diameter of the circle, i. e. *DC* : *AC* : : *CB* : *CE*.

Let the diameter *CE* be drawn, and join *EB*; it is plain the angle *CEB*=*CAB* (by cor. 2. theo. 7. geom.) and *CBE* is a right angle (by cor. 5. theo. 7. geom.) and=*ADC* : whence *ECB*=*ACD*. The triangles *CEB*, *CAD*, are therefore mutually equiangular, and (by theo. 16. geom.) *DC* : *AC* : : *CB* : *CE*, or *DC* : *CB* : : *AC* : *CE*. *Q. E. D.*

PROB. V.

Pl. 6. *fig.* 3.

Let three gentlemen's seats, *A*, *B*, *C*, be situate in a triangular form: there is given, *AB* 2.5 miles, *AC* 2.3, and *BC* 2. It is required to build a church at *E*, that shall be equi-distant from the seats *A*, *B*, *C*. What distance must it be from each seat, and by what angle may the place of it be found?

By Construction.

By prob. 15. geom. Find the centre of a circle that will pass through the points, A, B, C: and that will be the place of the church; the measure of which, to any of these points, is the answer for the distance: draw a line from any of the three points to the centre, and the angle it makes with either of the sides that contain the angle it was drawn to; that angle laid off by the direction of an instrument, on the ground, and the distance before found, being ranged thereon, will give the place of the church required.

By Calculation.

1. $AB : AC+BC :: AC-BC : AD-DB.$
   $2.5 \quad 4.3 \quad .3 \quad .516.$

$1.25+.258=1.508=AD.$

By cor. 2. theo. 14. geom. The square root of the difference of the squares of the hypothenuse AC, and given leg AD, will give DC.

That is, $5.29-2.274064=3.015936.$

Its square root is $1.736=CD.$

Then by the preceding lemma,

2. $CD : AC :: CB :$ the diameter.
   $1.736 \quad 2.3 \quad 2 \quad 2.65.$

the half of which, *viz.* 1.325 is the semi-diameter, or distance of the church from each seat, that is, AE, CE, BE.

From the centre E, let fall a perpendicular upon any of the sides as EF, and it will bisect in E: (by theo. 8. geom.)

Wherefore $AF=CF=\frac{1}{2}\ AC=1.15$.

In the right angled triangle AFE, you have AF 1.15, and AE the radius 1.325 given, to find FAE, thus;

3. $AF : R. :: AE :$ Sec. FAE.
1.15 90° 1.325 29° 47′.

Wherefore directing an instrument to make an angle of 29° 47′, with the line AC; and measuring 1.325 on that line of direction, will give the place of the church, or the centre of a circle that will pass through A, B, and C.

The above angle FAE, may be had without a secant, as before, thus;

$AE : R :: AF :$ S. AEF.
1.325 90° .115 60°. 13′.

Its complement 29°. 47′, will give FAE, as before.

The questions that may be proposed on this head, being innumerable, we have chosen to give only a few of the most useful.

SECTION III.

MENSURATION OF AREAS, OR THE VARIOUS METHODS OF CALCULATING THE SUPERFICIAL CONTENT OF ANY FIELD.

DEFINITION.

THE area or content of any plane surface, in perches, is the number of square perches which that surface contains.

Pl. 7. fig. 1.

Let *ABCD* represent a rectangular parallelogram, or oblong: let the side *AB*, or *DC*, contain 8 equal parts; and the side *AD*, or *BC*, three of such parts; let the line *AB* be moved in the direction of *AD*, till it has come to *EF*; where *AE*, or *BF* (the distance of it from its first situation) may be equal to one of the equal parts. Here it is evident, that the generated oblong *ABEF*, will contain as many squares as the side *AB* contains equal parts, which are 8; each square having for its side one of the equal parts, into which *AB*, or *AD*, is divided. Again, let *AB* move on till it comes to *GH*, so as *GE*, or *HF*, may be equal to *AE*, or *BF*; then it is plain that the oblong *AGHB*, will contain twice as many squares as the side *AB* contains equal parts. After the same manner it will appear, that the oblong *ADCB* will contain three times as many squares as the side *AB* contains equal parts; and in general, that every rectangular parallelogram, whether square or oblong, contains as many squares as the product of the number of equal parts in the base, multiplied into the number of the same equal parts in the height, contains units, each square having for its side one of the equal parts.

Hence arises the solution of the following problems.

PROB. I.

To find the content of a square piece of ground.

1. Multiply the base in perches, into the perpendicular in perches, the product will be the content in perches; and because 160 perches make an acre, it must thence follow, that

Any area, or content in perches, being divided by 160, will give the content in acres; the remaining perches, if more than 40, being divided by 40, will give the roods, and the last remainder, if any, will be perches.

Or thus:

2. Square the side in four-pole chains and links, and the product will be square four-pole chains and links: divide this by 10, or cut off one more than the decimals, which are five in all, from the right towards the left: the figures on the left are acres; because 10 square four-pole chains make an acre, and the remaining figures on the right, are decimal parts of an acre. Multiply the five figures to the right by 4, cutting 5 figures from the product, and if any figure be to the left of them, it is a rood, or roods; multiply the last cut off figures by 40, cutting off five, or (which is the same thing) by 4, cutting off four; and the remaining figures to the left, if any, are perches.

1. The first part is plain, from considering that a piece of ground in a square form, whose side is a perch, must contain a perch of ground; and that 40 such perches make a rood, and four roods an

acre ; or which is the same thing, that 160 square perches make an acre, as before.

2. A square four-pole chain (that is, a piece of ground four poles or perches every way) must contain 160 square perches ; and 160 perches make an acre, therefore 10 times 16 perches, or 10 square four-pole chains, make an acre.

* Note. The chains given, or required, in any of the following problems, are supposed to be two-pole chains, that chain being most commonly used; but they must be reduced to four-pole chains or perches for calculation, because the links will not operate with them as decimals.

Examples.

Pl. 1. *fig.* 17.

Ch. L.

Let $ABCD$ be a square field, whose side is 14 29, required the content in acres.

Ch. L.

By problem 4. section 1. part 2. 14. 29 are equal to

```
          29.16 perches
          29.16
          -----
          17496
          2916
        26244
        5832
        ---------                A. R. P.
   160)850.3056(                 5. 1. 10. content.
        -----
    40)50(1 rood.
        --
       10 perches.
```

Or thus:

Ch. L.	*Ch. L.*	
14. 29 are equal to	7. 29 of four-pole chains, by prob. 1. sect. 1. pt. 2.	
	7. 29	
	6561	
	1458	
	5103	
		A.R. P.
Acres	5|31441	cont. as before 5. 1. 10
	4	
Rood	1|25764	
	40	
Perches	10|30560	

It is required to lay down a map of this piece of ground, by a scale of twenty perches to an inch.

Take 29. 16 the perches of the given side, from the small diagonal on the common surveying scale, where 20 small, or two of the large divisions, are an inch: make a square whose side is that length (by prob. 9. geom.) and it is done.

PROB. II.

To find the side of a square, whose content is given.

Extract the square root of the given content in perches, and you have the side in perches, and consequently in chains.

EXAMPLE.

It is required to lay out a square piece of ground which shall contain 12A. 3R. 16P. Required the number of chains in each side of the square; and to lay down a map of it, by a scale of 40 perches to an inch.

```
   A.   R.   P.
   12.  3.   16.
    4
   ---
   51
   40
   ---                       Ch. L.
   2056(45.34+perches = 22. 33½ by prob. 6.
   ---
 85)456             [sect. 1. pt. 2.
   ---
903)3100
   ---
9064)39100 &c.
```

To draw the map.

From a scale where 4 of the large, or 40 of the small divisions are an inch, take 45.34, the perches of the side, of which make a square.

PROB. III.

To find the content of an oblong piece of ground.

Multiply the length by the breadth, for the content.

EXAMPLE.

Pl. 1. *fig.* 3.

Let *ABCD* be an oblong piece of ground, whose length *AB* is 14*C.* 25*L.* and breadth 8*C.* 37*L.* required the content in acres, and also to lay down a map of it, by a scale of 20 perches to an inch.

Ch. L.	*Perches.*	
14.25 =	29.00	By prob. 4. sect. 1. pt. 2.
8.37 =	17.48	

15732
3496

A. R. P.
160)506.9200(3. 0. 27. content.

26 perches, or near 27.

Or thus:

4 pole ch.		
Ch. L.	*Ch. L.*	
14.25 =	7.25	By prob. 1. sect. 1. pt. 2.
8.37 =	4.37	

5075
2175
2900

Acres 3|16825
4

Rood |67300
4

Perches 26|9200

To draw the map.

Make an oblong (by schol. to prob. 9. geom.) whose length, from a scale of 20 to an inch, may be 29 perches, and breadth, 17.48 perches.

PROB. IV.

The content of an oblong piece of ground, and one side given, to find the other.

Divide the content in perches, by the given side in perches, the quotient is the side required in perches; and thence it may be easily reduced to chains.

Example.

There is a ditch 14 *Ch.* 25 *L.* long, by the side of which it is required to lay out an oblong piece of ground, which shall contain 3A. 0R. 37P: what breadth must be laid off at each end of the ditch to enclose the 3A. 0R. 37P?

```
        A.   R.   P.
        3.   0.   27.
        4
       ---
       12
        40
      ----  Perch. Ch. L.
   29)507(17.48 = 8. 37. breadth.
      ----
       217
       ---
        140
        ---
         240
         ---
           8
```

The map is constructed like the last.

PROB. V.

To find the content of a piece of ground, in form of an oblique angular parallelogram; or of a rhombus, or rhomboides.

Multiply the base into the perpendicular height. The reason is plain from theo. 13. geom.

EXAMPLE.

PL. 7. fig. 2.

Let *ABCD* be a piece of ground in form of a rhombus, whose base *AB* is 22 chains, and perpendicular *DE*, or *FC*, 20 chains. Required the content.

$$\begin{array}{l} \textit{Ch.}\quad \textit{Ch.} \\ \left.\begin{array}{l} 22=11.0 \\ 20=10.0 \end{array}\right\} \text{ 4 pole chains.} \\ \hline \text{Acres } 11|0 \end{array}$$

Or,

$$\begin{array}{l} \textit{Ch.} \\ \left.\begin{array}{l} 22=44 \\ 20=40 \end{array}\right\} \text{ perches.} \\ \hline 160)1760(11 \text{ acres.} \\ \qquad\;\; 160 \\ \hline \qquad\quad 0 \end{array}$$

The converse of this is done by prob. 4. and the map is drawn, by laying off the perpendicular on that part of the base from whence it was taken; joining the extremity thereof to that of the base by a right line, and thence completing the parallelogram.

PROB. VI.

To find the content of a triangular piece of ground.

Multiply the base by half the perpendicular, or the perpendicular by half the base; or take half the product of the base into the perpendicular.

The reason of this is plain, from cor. 2. theo. 12. geom.

EXAMPLE.

Pl. 1. *fig.* 16.

Let *ABC* be a triangular piece of ground, whose longest side or base *BC*, is 24*C.* 38*L.* and perpendicular *AD*, let fall from the opposite angle, is 13 *C.* 28*L.* Required the content.

	Ch. L.		Ch. L.	
1. Base	24. 38	=	12. 38	4 pole chains.
		½ perp.	3. 39	
			11142	
			3714	
			3714	
		Acres	4|19682	
			4	
		Rood	|78728	
			40	
		Perches	31|49120	

A. R. P.
Content 4. 0. 31.

	Ch. L.	*Ch. L.*	
Perp.	13.28 =	6.78	four-pole chains by
½perp.	6.39 =	3.39	prob. 1. sect. 1. pt. 2.

Or 2dly. Perp. 6.78 of four-pole chains.
½base 6.19

```
      6102
      678
   4068
   -------    A.  R.  P.
   4|19682 = 4.  0.  31.
```

Or 3dly. Base 12.38 four-pole chains.
Perp. 6.78

```
      9904
     8666
    7428
    -------
    83.9364
    -------    A.  R.  P.
Its ½ = 4|19682 = 4.  0.  31.
```

Or the base and perpendicular may be reduced to perches; and the content may be thence obtained, thus:

	Ch. L.		*Perches.*	
Perp.	13.28	=	27.12	By prob. 4. sect. 1. pt. 2.
Half the perp.			13.56	

Perches. Ch. L.
1. Base 49.52 = 24.38
½ perp. 13.56

```
   29712
  24760
 14856
 4952
 ---------A.  R.  P.
160)671.4912(4.  0.  31.
    ----
     31
```

Perches.
2. Perp. 27.12
Half base 24.76

```
   16272
  18984
 10848
 5424
 --------  A.  R.  P.
 671.4912 = 4.  0.  31.
```

But, square perches may be reduced to acres, &c. rather more commodiously, by dividing by 40 and 4, than by 160; thus,

```
4|0)67|1.
4)16. 31
A. 4. 0. 31
```

	Perches.	
3.	Base	49.52
	Perp.	27.12

```
         9904
        4952
      34664
      9904
     ---------
     1342.9824
     ---------  A.  R.  P.
      671.4912 = 4.  0.  31.
```

The map may be readily drawn, having the distance from either end of the base, to the perpendicular given; as may be evident from the figure.

PROB. VII.

The content of a triangular piece of ground, and the base given, to find the perpendicular.

Divide the content in perches, by half the base in perches; and the quotient will give you the perpendicular, in perches and so in chains.

Examples.

Pl. 1. *fig.* 16.

Let *BC* be a ditch, whose length is 24*C.* 40*L.* by which it is required to lay out a triangular piece of ground, whose content shall be 4A. 1R. 10P. Required the perpendicular.

Ch. L. Perches.
Base 24.40 = 49.6
Half the base = 24.8

A. R. P.
4. 1. 10.
4
———
17
40
——— Perches.
24.8)690(27.28
———
1940
———
2040
———
560
———
64
———

Perches. Ch. L.
Answer perp. 27.28. = 13.45.

This perpendicular being laid on any part of the base, and lines run from its extremity to the ends of the base, will lay out the triangle (by cor. to theo. 13. geom.) so that the perpendicular may be set on that part of the base which is most convenient and agreeable to the parties concerned.

LEMMA.

Pl. 8. fig. 9.

If from half the sum of the sides of any plane triangle ABC, each particular side be taken; and if the half sum, and the three remainders be multiplied continually into each other, the square root of this product will be the area of the triangle.

Bisect any two of the angles, as *A* and *B*, with the lines *AB*, *BD* meeting in *D*; draw the perpendiculars *DE*, *DF*, *DG*.

The triangle *AFD* is equiangular to *AED*; for the angle *FAD*=*EAD* by construction, and *AFD*=*AED*, being each a right angle, and of consequence *ADF*=*ADE*; wherefore *AD* : *DE* : : *AD* : *DE* : and since *AD* bears the same proportion to *DF*, that it doth to *DE*, *DF*=*DE*, and the triangle *AFD*=*AED*. The same way *DE*=*DG*, and the triangle *DEB*=*DGB*, and *FD*=*DE*=*DG*; therefore *D* will be the centre of a circle that will pass through *E*, *F*, *G*.

In the same way if *A* and *C* were bisected, the same point *D* would be had; therefore a line from *D* to *C* will bisect *C*, and thus the triangles *DFC*, *DGC* will be also equal.

Produce *CA* to *H*, till *AH*=*EB* or *GB*; so will *HC* be equal to half the sum of the sides, *viz.* to $\frac{1}{2}$ *AB*, + $\frac{1}{2}$ *AC* + $\frac{1}{2}$ *BC*; for *FC*, *FA*, *EB*, are severally equal to *CG*, *AE*, *BG*; and all these together are equal to the sum of the sides of the triangle; therefore *FC* + *FA* + *EB* or *CH*, are equal to half the sum of the sides.

FC=*CH*—*AB*, for *AF*=*AE*, and *HA*=*EB*; therefore *HF*=*AB*; and *AF*=*CH*—*BC*; for *CF*

$=CG$, and $AH=GB$; therefore $BC=HA+FC$, and $AH = CH-AH$.

Continue DC, till it meets a perpendicular drawn upon H in K; and from K draw the perpendicular KI, and join AK.

Because the angles AHK and AIK are two right ones, the angles HIA and K together, are equal to two right; since the angles of the two triangles contain four right: in the same way $FDE+FAE=$(2 right angles$=$) $FAE+IAH$; let FAE be taken from both, then $FDE=IAH$, and of course $FAE = K$; the quadrilateral figures $AFDE$, and $KHAI$, are therefore similar, and have the sides about the equal angles proportional; and it is plain the triangles CFD and CHK are also proportional: hence,

$$FD : HA :: FA : HK$$
$$FD : FC :: HK : HC$$

Wherefore by multiplying the extreme, and means in both, it will be the square of $FD \times HK \times HC = FC \times FA \times HA \times HK$; let HK be taken from both, and multiply each side by CH; then the square of $CH \times$ by the square of $FD=FC\times FA\times HA\times CH$.

It is plain, by the foregoing problem, that $\frac{1}{2} AB \times DE$, $+\frac{1}{2} BC \times DG + \frac{1}{2} AC\times FD =$ the area of the triangle; or that half the sum of the sides, *viz.* $CH\times FD=$the triangle; wherefore the square of $CH \times$ by the square of $FD= FC\times FA\times HA \times CH$, that is, the half sum multiplied continually into the differences between the half sum and each side, will be the square of the area of the triangle, and its root the area. *Q. E. D.*

Hence the following problem will be evident.

PROB. VIII.

The three sides of a plane triangle given to find the area.

Rule.

From half the sum of the three sides subtract each side severally; take the logarithms of half the sum and three remainders, and half their total will be the logarithm of the area: or, take the square root of the continued product of the half sum and three remainders for the area.

Examples.

Pl. 8. fig. 9.

1. *In the triangle ABC, are*

Given, $\begin{cases} AB = 10.64 \\ AC = 12.28 \\ CB = 9.00 \end{cases}$ four-pole chains; required the area?

Sum	31.92		
Half sum	15.96	Log.	1.203033
Remainders	5.32	—	0.725912
	3.68	—	0.565848
	6.96	—	0.842609
			2)3.337402

Answer, Sqr. Ch. 46.63 Log. 1.668701
or, 4.663 Acres.

Or, $15.96 \times 5.32 \times 3.68 \times 6.96 = 2174.71113216$;

the square root of which is 46.63, for the area as before.

2. What quantity of land is contained in a triangle, the 3 sides of which are, 80, 120 and 160 perches respectively? Answer, 29A. 7P.

PROB. IX.

Two sides of a plane-triangle and their included angle given, to find the area.

Rule.

To the log. sine of the given angle (or of its supplement to 180°, if obtuse) add the logarithms of the containing sides; the sum, less radius, will be the logarithm of the double area.

Examples.

Pl. 5. *fig.* 16.

Suppose two sides, *AB*, *AC*, of a triangular lot *ABC*, form an angle of 30 degrees, and measure one 64 perches, and the other 40.5, what must the content be?

Given angle	30°.	sine	9.698970
Containing sides	64.	log.	1.806180
	40.5	log.	1.607455
	2)1296.	log.	3.112605

160)648(4A. 8P. answer.

8

2. Required the area of a triangle, two sides of which are 49.2 and 40.8 perches, and their contained angle 144¼ degrees? Answer, 3A. 2R. 22P.

3. What quantity of ground is inclosed in an equilateral triangle, each side of which is 100 perches, either angle being 60 degrees? Answer, 27A. 10P.

Demonstration of this problem.

Pl. 11. *fig.* 3.

Let *AH* be perpendicular to *AB* and equal to *AC*, and *HE*, *FCG*, parallel to *AB*; then making *AH* (= *AC*) radius, *AF* (= *CD*) will be the sine of *CAD*, and the parallelograms *ABEH* (the product of the given sides,) and *ABGF* the double area of the triangle) having the same base *AB*, are in proportion as their heights *AH*, *AF*; that is, as radius to the sine of the given angle; which proportion gives the operation as in the rule above.

PROB. X.

To find the area of a trapezoid, viz. a figure bounded by four right lines, two of which are parallel, but unequal.

Rule.

Multiply the sum of the parallel sides by their perpendicular distance, and take half the product for the area.

Note. On this 10th problem are founded most of the calculations of differences by latitude and departure, and those by offsets, following in this treatise.

EXAMPLES.

1. Required the area of a trapezoid, of which the parallel sides are, respectively, 30 and 49 perches, and their perpendicular distance 61.6?

$$\left.\begin{array}{r} 61.6 \\ 30+49 = 79. \end{array}\right\} \text{Multiply.}$$

$$2)4866.4$$

Answer, 2433.2=15A. 33.2P.

Pl. 9. *fig.* 10.

2. In the trapezoid *ABCD* the parallel sides are, *AD*, 20 perches, *BC*, 32, and their perpendicular distance, *AB*, 26; required the content?

Answer, 4A. 36P.

PROB. XI.

To find the Content of a trapezium.

RULE.

Multiply the diagonal, or line joining the remotest opposite angles, by the sum of the two perpendiculars falling from the other angles to that diagonal, and half the product will be the area.

EXAMPLE.

Pl. 7. *fig.* 3.

Let *ABCD* be a field in form of a trapezium, the diagonal *AC* 64.4 perches, the perpendicular *Bb* 13.6 and *Dd* 27.2, required the content?

$$\left.\begin{array}{r} \text{Diagonal} = 64.4 \\ 13.64+27.2 = 40.8 \end{array}\right\} \text{Multiply.}$$

$$2)2627.52$$

$$160)131376(8\text{A. } 33\tfrac{3}{4}\text{P. Answer.}$$
$$1280$$

$33\frac{3}{4}$ perches.

NOTE. The method of multiplying together the half sums of the opposite sides of a trapezium for the content is erroneous, and the more so the more oblique its angles are.

To draw the map set off *Ab* 28 perches, and *Ad* 34.4, and there make the perpendiculars to their proper lengths, and join their extremities to those of the diagonal.

PROB. XII.

To find the area of a circle, or an ellipsis.

RULE.

Multiply the square of the circle's diameter, or the product of the longest and shortest diameters of the ellipsis by .7854 for the area. Or, subtract 0.104909 from the double logarithm of the circle's diameter, or from the sum of the logarithms of those elliptic diameters, and the remainder will be the logarithm of the area.

Note. In any circle, the

$$\left.\begin{array}{l} \text{Diam. multi.} \\ \text{Circum. div.} \end{array}\right\} \text{by } 3.14159, \left\{\begin{array}{l} \text{produces the Cir.} \\ \text{quotes the diam.} \end{array}\right.$$

EXAMPLES.

1. How many acres are in a circle of a mile diameter?

1 Mile=320 per. log.	2.505150
	2.505150
	5.010300
	0.104909
4|0)8042|5. log.	4.905391
4)2010.25	

Answer, 502A. 2R. 25P.

2. A gentleman, knowing that the area of a circle is greater than that of any other figure of equal perimeter, walls in a circular deer park of 100 perches diameter, in which he makes an elliptical fish pond 10 perches long by 5 wide; required the length of his wall, content of his park, and area of his pond?

Answer, the wall 314.16 perches inclosing 49*A*. 14*P*. of which 39¼ perches, or ¼ of an acre nearly, is appropriated to the pond.

PROB. XIII.

The area of a circle given, to find its diameter.

RULE.

To the logarithm of the area add 0.104909, and half the sum will be the logarithm of the diameter. Or, divide the area by .7854, and the square-root of the quotient will be the diameter.

EXAMPLES.

A horse in the midst of a meadow suppose,
Made fast to a stake by a line from his nose.
How long must this line be, that feeding all
round,
Permits him to graze just an acre of ground?

Area in perches 160 log. 2.204120
0.104909

2)2.309029

2)
Diameter 14.2733 log. 1.154514

Answer, 7.13665 per. = 117F. 9 In.

PROB. XIV.

Allowance for roads.

It is customary to deduct 6 acres out of 106 for roads; the land before the deduction is made may be termed the *gross*, and that remaining after such deduction, the *neat*.

RULE.

The gross div. } by 1.06, { quotes the neat.
The neat mul. } by 1.06, { prod. the gross.

EXAMPLES.

1. How much land must I inclose to have 850A 2R. 20P. neat?

40|20.
4| 2.5

Acres. A. R. P.
850.625×1.06=901.6625=901.2.26. the ans.

2. How much neat land is there in a tract of 901A. 2R. 26P. gross?

40|26.
4| 2.65

Acres. A. R. P.
1.06)901.6625(850.625=850. 2. 20. the answ.
848

&c.

NOTE. These two operations prove each other.

PROB. XV.

To find the area of a piece of ground be it ever so irregular by dividing it into triangles and trapezia.

PL. 7. fig. 4.

We here admit the survey to be taken and protracted; by having therefore the map, and knowing the scale by which it was laid down, the content may be thus obtained.

Dispose the given map into triangles, by fine pencilled lines, such as are here represented in the scheme, and number the triangles with 1, 2, 3, 4, &c. Your map being thus prepared, rule a table with four columns; the first of which is for the number of the triangle, the second for the base of it, the third for the perpendicular, and the fourth for the content in perches.

Then proceed to measure the base of number 1, from the scale of perches the map was laid down, and place that in the second column of the table, under the word base; and from the angle opposite to the base, open your compasses so, as when one foot is in the angular point, the other being moved backwards and forwards, may just touch the base line, and neither go the least above or beneath it; that distance in the compasses measured from the same scale, is the length of that perpendicular, which place in the third column, under the word perpendicular.

If the perpendiculars of two triangles fall on one and the same base, it is unnecessary to put down the base twice, but insert the second perpendicular opposite to the number of the triangles in the table, and join it with the other perpendicular by a brace, as No. 1 & 2, 4 & 5, 6 & 7, 9 & 10, *&c.*

Proceed after this manner, till you have measured all the triangles; and then by prob. 6. find the content in perches of each respective triangle, which severally place in the table opposite to the number of the triangle, in the fourth column, under the word content.

But where two perpendiculars are joined together in the table, by a brace having both one and the same base; find the content of each (being a trapezium) in perches, by prob. 11. which place opposite the middle of those perpendiculars, in the fourth column, under the word content.

Having thus obtained the content of each respective triangle and trapezium, which the map contains, add them all together, and their sum will

be the content of the map in perches; which being divided by 160, gives the content in acres. Thus, for

Examples.

No.	Base.	Perpend.	Content.
1	24.8	17.0	412.92
2		16.3	
3	28.2	16.0	225.6
4	39.8	19.6	712.42
5		16.2	
6	49.4	29.0	1086.8
7		15.0	
8	38.7	6.7	129.64
9	40.0	17.0	600.
10		13.0	
11	42.8	10.2	481.5
12		12.3	
13	26.2	17.9	234.49
14	24.0	11.6	259.2
15		10.0	
Content in perches			4142.57

This being divided by 160, will give 25A. 3R. 22P. the content of the map.

Let your map be laid down by the largest scale your paper will admit, for then the bases and perpendiculars can be measured with greater accuracy than when laid down by a smaller scale, and if possible measure from scales divided diagonally.

If the bases and perpendiculars were measured by four-pole chains, the content of every triangle

and trapezium, may be had as before, in problems 6. and 11. and consequently the whole content of the map.

If any part of your map has short or crooked bounds, as those represented in plate 7. fig. 5. then by the straight edge of a transparent horn, draw a fine pencilled line as *AB* to balance the parts taken and left out, as also another, *BC*: these parts when small, may be balanced very nearly by the eye, or they may be more accurately balanced by method the third. Join the points *A* and *C* by a line, so will the content of the triangle *ABC*, be equal to that contained between the line *AC*, and the crooked boundary from *A* to *B*, and to *C*: by this method the number of triangles will be greatly lessened, and the content become more certain; for the fewer operations you have, the less subject will you be to err: and if an error be committed, the sooner it may be discovered.

The lines of the map should be drawn small, and neat, as well as the bases; the compasses neatly pointed, and scale accurately divided; without all which you may err greatly. The multiplications should be run over twice at least, as also the addition of the column content.

From what has been said, it will be easy to survey a field, by reducing it into triangles, and measuring the bases and perpendiculars by the chain. To ascertain the content only, it is not material to know at what part of the base the perpendicular was taken: since it has been shewn (in cor. to theo. 13. geom.) that triangles on the same base, and between the same parallels, are equal; but if you would draw a map from the bases and perpen-

diculars, it is evident that you must know at what part of the base the perpendicular was taken, in order to set it off in its due position; and hence the map is easily constructed.

PROB. XVI.

To determine the area of a piece of ground, having the map given, by reducing it to one triangle equal thereto, and thence finding its content.

PL. 8. fig. 5.

Let *A B C D E F G H* be a map of ground, which you would reduce to one triangle equal thereto.

Produce any line of the map, as *AH*, both ways, lay the edge of a parallel ruler, from *A* to *C*, having *B* above it; hold the other side of the ruler, or that next you, fast; open till the same edge touches *B*, and by it, with a protracting pin, mark the point *b*, on the produced line, lay the edge of the ruler from *b* to *D*, having *C* above it, hold the other side fast, open till the same edge touches *C*, and by it mark the point *c*, on the produced line. A line drawn from *c* to *D* will take in as much as it leaves out of the map.

Again lay the edge of the ruler from *H* to *F*, having *G* above it, keep the other side fast, open till the same edge touches *G*, and by it mark the point *g*, on the produced line; lay the edge of the ruler from *g* to *E*, having *F* above it, keep the other side fast, open till the same edge touches *F*, and by it mark the point *f*, on the produced line. Lay the edge of the ruler from *f* to *D*, having *E*

above it, keep the other side fast, open till the same edge touches *E*, and by it mark the point *e*, on the produced line. A line drawn from *D* to *e*, will take in as much as it leaves out. Thus have you the triangle *c D e*, equal to the irregular polygon *A B C D E F G H*.

If when the ruler's edge be applied to the points *A* and *C*, the point *B* falls under the ruler, hold that side next the said points fast, and draw back the other to any convenient distance; then hold this last side fast, and draw back the former edge to *B*, and by it mark *b*, on the produced line; and thus a parallel may be drawn to any point under the ruler, as well as if it were above it. It is best to keep the point of your protracting pin in the last point in the extended line, till you lay the edge of the ruler from it to the next station, or you may mistake one point for another.

This may also be performed with a scale, or ruler, which has a thin sloped edge, called a fiducial edge; and a fine pointed pair of compasses. Thus,

Lay that edge on the points *A* and *C*, take the distance from the point *B* to the edge of the scale, so that it may only touch it, in the same manner as you take the perpendicular of a triangle; carry that distance down by the edge of the scale parallel to it, to *b*; and there describe an arc on the point *b*; and if it just touches the ruler's edge, the point *b* is in the true place of the extended line. Lay then the fiducial edge of the scale from *b* to *D*, and take a distance from *C*, that will just touch the edge of the scale; carry that distance along the edge, till the point which was in *C*, cuts the produced line in *c*; keep that foot in *c*, and

describe an arc, and if it just touches the ruler's edge, the point *c* is in the true place of the extended line. Draw a line from *c* to *D*, and it will take in and leave out equally: in like manner the other side of the figure may be balanced by the line *e D*.

Let the point of your compasses be kept to the last point of the extended line, till you lay your scale from it to the next station, to prevent mistakes from the number of points.

That the triangle *c D e*, is equal to the right-lined figure *ABCDEFGH*, will be evident from problems 18. 19. geom. for thereby, if a line were drawn from *b* to *C*, it will give and take equally, and then the figure *b C D E F G H*, will be equal to the map. Thus the figure is lessened by one side, and by the next balance line will lessen it by two, and so on, and will give and take equally. In the same manner an equality will arise on the other side.

The area of the triangle is easily obtained, as before, and thus you have the area of the map.

It is best to extend one of the shortest lines of the polygon, because if a very long line be produced, the triangle will have one angle very obtuse, and consequently the other two very acute; in which case it will not be easy to determine exactly the length of the longest side, or the points where the balancing lines cut the extended one.

This method will be found very useful and ready in small enclosures, as well as very exact; it may be also used in large ones, but great care must be taken of the points on the extended line, which will be crowded, as well as of not missing a station.

PROB. XVII.

A map with its area being given, and its scale omitted to be either drawn or mentioned; to find the scale.

CAST up the map by any scale whatsoever, and it will be

As the area found
Is to the square of the scale by which you cast up,
: : The given area of the map
To the square of the scale by which it was laid down.

The square root of which will give the scale.

Example.

A map whose area is 126A. 3R. 16P. being given; and the scale omitted to be either drawn or mentioned; to find the scale.

Suppose this map was cast up by a scale of 20 perches to an inch, and the content thereby produced be 31A. 2R. 34P.

As the area found, 31A. 2R. 34P.=5074P.
Is to the square of the scale by which it was cast up, that is to 20×20=400,
: : The given area of the map 126A. 3R. 16P. =20296P.

To the square of the scale by which it was laid down.

5074 : 400 : : 20296 : 1600 the square of the required scale.

Root.
1600(40
16
———
8(00
———

Answer. The map was laid down by a scale of 40 perches to an inch.

PROB. XVIII.

How to find the true content of a survey, though it be taken by a chain that is too long or too short.

Let the map be constructed, and its area found as if the chain were of the true length. And it will be,

As the square of the true chain
Is to the content of the map,
: : The square of the chain you surveyed by
To the true content of the map.

Example.

If a survey be taken with a chain which is 3 inches too long; or with one whose length is 42 feet 3 inches, and the map thereof be found to contain 920A. 2R. 20P. Required the true content.

As the square of 42F. 0In.=the square of 504 inches=254016.
Is to the content of the map 920A. 1R. 20P.= 147260P.
: : The square of 42F. 3In.=the square of 507 inches=257049.
To the true content.

$$\begin{array}{cccc} & \text{P.} & & \text{P.} \\ 250416 : & 147260 :: & 257049 : & 149019 \end{array}$$

$$\begin{array}{l} \qquad\qquad\qquad\qquad\quad \text{A.} \quad \text{R.} \quad \text{P.} \\ 160)149019(931. \quad 1. \quad 19 \text{ Answer.} \\ \underline{\qquad\qquad} \\ \quad\;\; 501 \\ \quad\;\; \underline{\quad\;\;} \\ \qquad 219 \\ \qquad \underline{\quad\;\;} \\ 40)59(1\text{R.} \\ \qquad \underline{\quad\;\;} \\ \qquad 19\text{P.} \end{array}$$

Method of determining the Areas of right-lined Figures universally, or by calculation.

DEFINITIONS.

Pl. 8. *fig.* 7.

1. MERIDIANS are north and south lines, which are supposed to pass through every station of the survey.

2. The difference of latitude, or the northing or southing of any stationary line, is the distance that one end of the line is north or south from the other end; or it is the distance which is intercepted on the meridian, between the beginning of the stationary line and a perpendicular drawn from the other end to that meridian. Thus, if *N. S.* be a meridian line passing through the point *A* of the line *AB*, then is *Ab* the difference of latitude or southing of that line,

3. The departure of any stationary line, is the nearest distance from one end of the line to a meridian passing through the other end. Thus *Bb* is the departure or easting of the line *AB*: but if *CB* be a meridian, and the measure of the stationary distance be taken from *B* to *A*; then is *BC* the difference of latitude, or northing, and *AC* the departure or westing of the line *BA*.

4. That meridian which passes through the first station, is sometimes called the first meridian; and sometimes it is a meridian passing on the east or west side of the map, at the distance of the breadth thereof, from east to west, set off from the first station.

5. The meridian distance of any station is the distance thereof from the first meridian, whether it be supposed to pass through the first station, or on the east or west side of the map.

THEO. I.

In every survey which is truly taken, the sum of the northings will be equal to that of the southings; and the sum of the eastings equal to that of the westings.

Pl. 9. fig. 1.

Let *a*, *b*, *c*, *e*, *f*, *g*, *h*, represent a plot or parcel of land. Let *a* be the first station, *b* the second, *c* the third, *&c.* Let *NS* be a meridian line, then will all lines parallel thereto, which pass through the several stations, be meridians also; as *ao*, *bs*, *cd*, *&c.* and the lines *bo*, *cs*, *de*, *&c.* perpendicular to those, will be the east or west lines, or departures.

The northings, $ei+go+hq=ao+bs+cd+fr$ the southings: for let the figure be completed; then it is plain that $go+hq+rk=ao+bs+cd$, and $ei-rk=fr$. If to the former part of this first equation $ei-rk$ be added, and fr to the latter, then $go+hq+ei=ao+bs+cd+fr$; that is, the sum of the northings is equal to that of the southings.

The eastings $cs+qa=ob+de+if+rg+oh$, the westings. For $aq+yo$ $(az)=de+if+rg+oh$, and $bo=cs-yo$. If to the former part of this first equation, $cs-yo$ be added, and bo to the latter, then $cs+aq=ob+de+if+rg+oh$; that is, the sum of the eastings is equal to that of the westings. *Q. E. D.*

SCHOLIUM.

This theorem is of use to prove whether the field-work be truly taken, or not; for if the sum of the northings be equal to that of the southings, and the sum of the eastings to that of the westings, the field-work is right, otherwise not.

Since the proof and certainty of a survey depend on this truth, it will be necessary to shew how the difference of latitude and departure for any stationary line, whose course and distance are given, may be obtained by the table, usually called the Traverse Table.

To find the difference of Latitude and departure, by the Traverse Table.

This table is so contrived, that by finding therein the given course, and a distance not exceeding 120 miles, chains, perches, or feet, the difference of latitude and departure is had by inspection: the course is to be found at the top of the table when under 45 degrees; but at the bottom of the table when above 45 degrees. Each column signed with a course consists of two parts, one for the

difference of latitude, marked Lat. the other for the departure, marked Dep. which names are both at the top and bottom of these columns. The distance is to be found in the column marked Dist. next the left hand margin of the page.

EXAMPLE.

In the use of this table, a few observations only are necessary.

1. If a station consist of any number of even chains or perches (which are almost the only measures used in surveying) the latitude and departure are found at sight under the bearing or course, if less than 45 degrees; or over it if more, and in a line with the distance.

2. If a station consist of any number of chains and perches, and decimals of a chain or perch, under the distance 10, the lat. and dep. will be found as above, either over or under the bearing; the decimal point or separatrix being removed one figure to the left, which leaves a figure to the right to spare.

If the distance be any number of chains or perches, and the decimals of a chain or perch, the lat. and dep. must be taken out at two or more operations, by taking out the lat. and dep. for the chains or perches in the first place; and then for the decimal parts.

To save the repeated trouble of additions, a judicious surveyor will always limit his stations to whole chains, or perches and lengths, which can commonly be done at every station, save the last.

1. In order to illustrate the foregoing observations, let us suppose a course or bearing, to be *S.* 35°. 15′ *E.* and the distance 79 four-pole chains. Under 35°. 15′, or $35\frac{1}{4}$ degrees; and opposite 79, we find 64. 52 for the latitude, and 45. 59 the departure, which signify that the end of that station differ in latitude from the beginning 64. 52 chains, and in departure 45. 59 chains.

Note. We are to understand the same things if the distance is given in perches or any other measures, the method of proceeding being exactly the same in every case.

Again, let the bearing be $54\frac{3}{4}$ degrees and distance as before; then over said degrees we find the same numbers, only with this difference, that the lat. before found, will now be the dep. and the dep. the lat. because $54\frac{3}{4}$ is the complement of $35\frac{1}{4}$ degrees to 90, *viz.* lat. 45. 59. dep. 64. 52.

2. Suppose the same course, but the distance 7 chains 90 links, or as many perches. Here we find the same nnmbers, but the decimal point must be removed one figure to the left.

Thus, under $35\frac{1}{4}$, and in a line with 79 or 7.9, are

Lat. 6. 45
Dep. 4. 56

the 5 in the dep. being increased by 1, because the 9 is rejected; but over $54\frac{3}{4}$ we get

Lat. 4. 56
Dep. 6. 45

3. Let the course be as before, but the distance 7.79, then opposite

7. 70	Lat. 6. 29	Dep. 4. 43
9	7	6
7. 79	6. 36	4. 49

Or opposite

7. 00	Lat. 5. 72	Dep. 4. 03
. 79	. 64	. 46
7. 79	6. 36	4. 49

THEO. II.

When the first meridian passes through the map.

If the east meridian distances in the middle of each line be multiplied into the particular southing, and the west meridian distances into the particular northing, the sum of these products will be the area of the map.

Pl. 10. *fig.* 1.

Let the figure *abkm* be a map, the lines, *ab bk* to the southward, and *km ma* to the northward, NS the first meridian line passing through the first station *a*.

$$\left.\begin{array}{r}\text{The meridian}\\ \text{Distances east}\end{array}\right\}\left.\begin{array}{l} zd\times ao\\ tu\times ox(by)\end{array}\right\}=\text{Area}\left\}\begin{array}{l} am\\ ow\end{array}\right.$$

$$\left.\begin{array}{r}\text{The meridian}\\ \text{Distances west}\end{array}\right\}\left.\begin{array}{l} ef\times gx\\ hh\times ga(my)\end{array}\right\}=\text{Area}\left\}\begin{array}{l} xp\\ gl\end{array}\right.$$

These four areas *am+ow+xp+gl* will be the area of the whole figure *cmswiprlc*, which is equal to the area of the map *abkm*. Complete the figure.

The parallelograms *am* and *ow*, are made of the east meridian distances *ds* and *tu*, multiplied into the southings *ao* and *ox*. The parallelograms *xp* and *gl* are composed of the west meridian distances *ef* and *hh*, multiplied into the northings *xg* and *ga* (*my*) but these four parallelograms are equal to the area of the map; for if from them be taken the four triangles marked *Z*, and in the place of those be substituted the four triangles marked *O*, which are equal to the former; then it is plain the area of the map will be equal to the four parallelograms. *Q. E. D.*

THEO. III.

If the meridian distance when east, be multiplied into the southings, and the meridian distance when west be multiplied into the northings, the sum of these less by the meridian distance when west, multiplied into the southings, is the area of the survey.

Pl. 10. *fig.* 2.

Let *ab c* be the map.

The figure being completed, the rectangle *af* is made of the meridian distance *eq* when east, multiplied into the southing *an*; the rectangle *yk* is made of the meridian distance *xw*, multiplied into the northings *cz* or *ya*. These two rectangles, or parallelograms, *af+yk*, make the area of the figure *dfnyikd*, from which taking the rectangle *oy*, made of the meridian distance *tu* when west, into the southings *oh* or *bm*, the remainder is the area of the figure *dfohikd*, which is equal to the area of the map.

Let *bou*$=Y$, *urih*$=L$, *ric*$=O$, *wrc*$=Z=$, *akw*$=K$, and *efb*$=B$, *ade*$=A$. I say, that $Y+Z+B=K+L+A$.

$Y=L+O$, add Z to both, then $Y+Z=L+O+Z$; but $Z+O=K$, put K instead of $Z+O$; then $Y+Z=L+K$, add to both sides the equal triangles B and A, then $Y+Z+B=L+K+A$. If therefore $B+Y+Z$ be taken from abc, and in lieu thereof we put $L+K+A$, we shall have the figure *dfohikd*= *abc*, but that figure is made up of the meridian distance when east, multiplied into the southing, and the meridian distance, when west, multiplied into the northing less by the meridian distance, when west, multiplied into the southing. *Q. E. D.*

COROLLARY.

Since the meridian distance (when west) multiplied into the southing, is to be subtracted, by the same reasoning the meridian distance when east, multiplied into the northing, must be also subtracted.

SCHOLIUM.

From the two preceding theorems we learn how to find the area of the map, when the first meridian passes through it; that is, when one part of the map lies on the east and the other on the west side of that meridian. Thus,

Rule.

$$\left.\begin{matrix}\text{The merid.}\\ \text{Dist. when}\end{matrix}\right\}\begin{matrix}\text{east}\\ \text{west}\end{matrix}\left\{\begin{matrix}\text{multiplied}\\ \text{into the}\end{matrix}\right.\left\{\begin{matrix}\text{southings}\\ \text{northings}\end{matrix}\right\}$$

their sum is the area of the map.

But,

$$\begin{matrix}\text{The merid.}\\ \text{Dist. when}\end{matrix}\left\{\begin{matrix}\text{east}\\ \text{west}\end{matrix}\right\}\begin{matrix}\text{multiplied}\\ \text{into the}\end{matrix}\left\{\begin{matrix}\text{northings}\\ \text{southings}\end{matrix}\right\}$$

the sum of these products taken from the former gives the area of the map.

These theorems are true, when the surveyor keeps the land he surveys, on his right hand, which we suppose through the whole to be done; but if he goes the contrary way, call the southings northings, and the northings southings, and the same rule will hold good.

General Rule for finding the Meridian distances.

1. The meridian distance and departure, both east, or both west, their sum is the meridian distance of the same name.

2. The meridian distance and departure of different names; that is, one east and the other west, their difference is the meridian distance of the same name with the greater.

Thus in the first method of finding the area, as in the following field-book.

The first departure is put opposite the northing or southing of the first station, and is the first meridian distance of the same name. Thus if the first departure be east, the first meridian distance will be the same as the departure, and east also; and if west, it will be the same way.

The first meridian distance	6.61 E.
The next departure	6.61 E.
The second meridian distance	13.22 E.
The next departure	1.80 E.
The third meridian distance	15.02 E.

At station 5, the meridian distance	5.78 E.
The next departure	7.76 W.
The next meridian distance	1,98 W.

At station 11, the meridian distance	0.12 W.
The next departure	5.84 E.
The next meridian distance	5.72 E.

Pl. 10. fig. 3.

In the 5th and 11th stations, the meridian distance being less than the departures, and of a contrary name, the map will cross the first meridian, and will pass as in the 5th line, from the east to the west line of the meridian; and in the 11th line it will again cross from the east to the west side, which will evidently appear, if the field-work be protracted, and the meridian line passing through the first station, be drawn through the map.

The field-book cast up by the first method, will be evident from the two foregoing theorems, and therefore requires no further explanation; but *to find the area, by the second method,* take this

Rule.

When the meridian distances are east, put the products of north and south areas in their proper columns; but when west, in their contrary columns; that is, in the column of south area, when the difference of latitude is north; and in north when south: the reason of which is plain, from the two last theorems. The difference of these two columns will be the area of the map.

No. St.	Bearings.	C. L.	Lat. and half Dep	Merid Dist	Area.	Deduct.
1	NE 75	13.70	N 3.54 E 6.61	6.61 E 13.22 E		23.3994
2	NE 20½	10.30	N 9.67 E 1.80	15.02 E 16.82 E		144.9430
3	East	16.20	0.00 E 8.10	24.92 E 33.02 E		
4	SW 33½	35.30	S 29.44 W 9.74	23.28 E 3.54 E	685.3632	
5	SW 76	16.00	S 3.87 W 7.76	5.78 E 1.98 W	22.3686	
6	North	9.00	N 9.00 0.00	1.98 W 1.98 W	17.8200	
7	SW 84	11.60	S 1.21 W 5.77	7.75 W 13.52 W		9.3775
8	NW 53¼	11.60	N 6.94 W 4.64	18.16 W 22.80 W	126.0304	
9	NE 36¾	19.20	N 15.38 E 5.74	17.06 W 11.32 W	262.3828	
10	NE 22½	14.00	N 12.93 E 2.68	8.64 W 5.96 W	111.7152	
11	SE 76¾	12.00	S 2.75 E 5.84	0.12 W 5 72 E		0.3300
12	SW 15	10.85	S 10.48 W 1.40	4.32 E 2.92 E	45.2736	
13	SW 16¾	10.12	S 9.69 W 1.46	1.46 E 0.00	14.1474	
					1285.1012 178.0499	178.0499
		Content in Chains,			1107.0513	

It is needless here to insert the columns of bearing or distances in chains, they being the same as before.

No. St.	Lat. and half Dep.	Merid. Dist.	N. Area.	S. Area.
1	N 3.54 E 6.61	6.61 E 13.22 E	23.3994	
2	N 9.65 E 1.80	15.02 E 16.82 E	144.9430	
3	0.00 E 8.10	24.92 E 33.02 E		
4	S 29.44 W 9.74	23.28 E 13.54 E		685.3632
5	S 3.87 W 7.76	5.78 E 1.98 W		22.3686
6	N 9.00 0.00	1.98 W 1.98 W		17.8200
7	S 1.21 W 5.77	7.75 W 13.52 W	9.3775	
8	N 6.94 W 4.64	18.16 W 22.80 W		126.0308
9	N 15.38 E 5.74	17.06 W 11.32 W		262.3828
10	N 12.93 E 2.68	8.64 W 5.96 W		111.7152
11	S 2.75 E 5.84	0.12 W 5.72 E	0.3300	
12	S 10.48 W 1.40	4.32 E 2.92 E		45.2736
13	S 9.69 W 1.46	1.46 E 0.00		14.1474
			178.0499	[illegible]284.1012
				178 0499
Area in chains, as before,				1107.0513

Construction of the Map from either the 1st or the 2d Table;

Pl. 10. fig. 3.

Draw the line NS for a north and south line, which call the first meridian; in this line assume any point, as 1, for the first station. Set the northing of that stationary line, which is 3.54, from 1 to 2, on the said meridian line. Upon the point 2 raise a perpendicular to the eastward, the meridian distance being easterly, and upon it set 13.22, the second number in the column of meridian distance from 2 to 2, and draw the line 1 2, for the first distance line: from 2 upon the first meridian, set the northing of the second stationary line, that is, 9.65 to 3, and on the point 3 erect a perpendicular eastward, upon which let the meridian distance of the second station 16.82, from 3 to 3, and draw the line 2 3, for the distance line of the second station. And since the third station has neither northing nor southing, set the meridian distance of it 33.02, from 3 to 4, for the distance line of the third station. To the fourth station there is 29.44, southing, which set from 3 to 5; upon the point 5, erect the perpendicular 5 5; on which lay 13,54, and draw the line 4 to 5.

In the like manner proceed to set the northings and southings on the first meridian, and the meridian distances upon the perpendiculars raised to the east or west; the extremities of which connected by right lines, will complete the map.

A Specimen of the Pennsylvania Method of CALCULATION; which, for its Simplicity and Ease, in finding the Meridian Distances, is supposed to be preferable in Practice to any Thing heretofore published on the Subject.

FIND in the first place, by the Traverse Table, the lat. and dep. for the several courses and distances, as already taught; and if the survey be

truly taken, the sums of the northings and southings will be equal, and also those of the eastings and westings. Then, in the next place, find the meridian distances, by choosing such a place in the column of eastings or westings, as will admit of a continual addition of one, and subtraction of the other; by which means we avoid the inconvenience of changing the denomination of either of the departures.

The learner must not expect that in real practice the columns of lat. and those of dep. will exactly balance when they are at first added up, for little inaccuracies will arise, both from the observations taken in the field, and in chaining; which to adjust, previous to finding the meridian distances, we may observe, That if, in small surveys, the difference amount to two-tenths of a perch for every station, there must have been some error committed in the field; and the best way in this case, will be to rectify it on the ground by a re-survey, or at least as much as will discover the error. But when the differences are within those limits, the columns of northing, southing, easting, and westing, may be corrected as follows:

Add all the distances into one sum, and say, as that sum is to each particular distance, so is the difference between the sums of the columns of northing and southing to the correction of northing or southing belonging to that distance: the corrections thus found are respectively additive, when they belong to the column of northing or southing, which is the less of the two, and subtractive when they belong to the greater; if the course be due east or west, the correction is always additive to the less of the two columns of northing or southing. The corrections of easting and westing are found exactly in the same manner.

This rule was investigated two different ways, by N. Bowditch, Author of the Practical Navigator, and R. Adrain, Prof. Math. and N. Phil. Columbia Col. N. York, as may be seen in the Analyst No. IV. published in 1808.

The following example will sufficiently illustrate the manner of applying the rule.

In this example the sum of the distances is 791, and the difference between the columns of northing and southing, is .4, also the first distance is 70; say then,

791 : 70 : : .4 : .04

which fourth proportional .04 is the first correction belonging to the southing 53.6, from which the correction .04 should be subtracted.

In this manner the several corrections of the southings

$$\left.\begin{matrix}53.6\\29.1\\135.7\end{matrix}\right\}\text{ are found to be }\left\{\begin{matrix}.04\\.09\\.07\end{matrix}\right\}\text{ respectively.}$$

But as only two of these corrections amount to half a tenth, we must use .1 for each of the corrections .09 and .07, and neglect the correction .04; thus the correct southings become

$$\left.\begin{matrix}53.6\\29.0\\135.6\end{matrix}\right\}$$

In like manner from the remaining distances we obtain to

$$\text{the northings }\left.\begin{matrix}62.9\\101.1\\54.0\\00.0\end{matrix}\right\}\text{ the additive corrections }\left\{\begin{matrix}.04\\.06\\.03\\.07\end{matrix}\right\}$$

And consequently, by neglecting .04, and .03, and using .1 for each of the two .06 and .07, the northings

$$\text{when corrected are}\left.\begin{matrix}62.9\\101.2\\54.0\\00.1\end{matrix}\right\}$$

In obtaining these corrections, it is commonly unnecessary to use all the significant figures of the distances: thus, for the ratio of 791 to 70, we may say, as 80 to 7.

EXAMPLE OF CORRECTING A SURVEY.

Field-Notes.			From the Tables.				Corrected.			
No.	Courses.	Distin Per.	N.	S.	E.	W.	N.	S.	E.	W.
1	S. 40° W.	70		53.6		45.0		53.6		45.0
2	N. 45 W.	89	62.9			62.9	62.9			62.9
3	N. 36 E.	125	101.1		73.5		101.2		73.5	
4	North.	54	54.0				54.0			
5	S. 81 E.	186		29.1	183.7			29.0	183.6	
6	S. 8 W.	137		135.7		19.1		135.6		19.2
7	West.	130				130.0	00.1			130.0
			218.0	218.4	257.2	257.0	218.2	218.2	257.1	257.1
				218.0	257.0					
			Diff.	=.4	.2	=Diff.				

The latitudes and departures being thus balanced, proceed to insert the meridian distances by the above method, where we still make use of the same field notes, only changing chains and links into perches and tenths of a perch. Then by looking along the column of departure, it is easy to observe, that in the columns of easting, opposite station 9, all the eastings may be added, and the westings subtracted, without altering the denomination of either. Therefore by placing 46.0, the east departure belonging to this station in the column of meridian distances, and proceeding to add the eastings and subtract the westings, according to the rule already mentioned, we shall find that at station 8, these distances will end in 0, 0, or a cypher, if the additions and subtractions be rightly made. Then multiplying the upper meridian distance of each station by its respective northing or southing, the product will give the north or south area, as in the examples already insisted on, and which is fully exemplified in the annexed specimen. When these products are all made out, and placed in their respective columns, their difference will give double the area of the plot, or twice the number of acres contained in the survey. Divide this remainder by 2, and the quotient thence arising by 160 (the number of perches in an acre), then will this last quotient exhibit the number of acres and perches contained in the whole survey; which in this example may be called 110 acres, 103 perches, or 110 acres, 2 quarters, 23 perches.

FIELD-NOTES, of the two foregoing Methods, as Practised in Pennsylvania.

Cast up by perches and tenths of a perch.

N.	Courses.	Dist.	N.	S.	E.	W.	MD.	N. Area.	S. Areas.
1	N 75.00 E	54.8	14.2		52.9		235.3 288.2	3341.26	
2	N 20.30 E	41.2	38.6		14.4		302.6 317.0	11680.36	
3	East.	64.8			64.8		381.8 446.6		
4	S 33.30 W	141.2		117.7		77.9	368.7 290.8		43395.99
5	S 76.00 W	64.0		15.5		62.1	228.7 166.6		3544.85
6	North.	36.0	36.0				166.6 166.6	5977.60	
7	S 84.00 W	46.4		4.9		46.1	120.5 74.4		590.45
8	N 53.15 W	46.4	27.8			37.2	37.2 00.0	1034.16	
9	N 36.45 E	76.8	61.5		46.0		46.0 92.0	2829.00	
10	N 22.30 E	56.0	51.7		21.4		113.4 134.8	5862.78	
11	S 76.45 E	48.0		11.0	46.7		181.5 228.2		1996.50
12	S 15.00 W	43.4		41.9		11.2	217.0 205.8		9092.30
13	S 16.45 W	40.5		38.8		11.7	194.1 182.4		7531.08
			229.8	229.8	246.2	246.2		30745.16	36151.17 30745.16
								2	5406.01
								Area in perches.	17703.05

SECTION IV.

OF OFF-SETS.

IN taking surveys it is unnecessary and unusual to make a station at every angular point, because the field-work can be taken with much greater expedition, by using off-sets and intersections, and with equal certainty; especially where creeks, &c. bound the survey.

Off-sets are perpendicular lines drawn or measured from the angular points of the land, that lie on the right or left hand to the stationary distance, thus,

Pl. 11. *fig.* 2.

Let the black lines represent the boundaries of a farm or township: and let 1 be the first station; then if you have a good view to 2, omit the angular points between 1 and 2, and take the bearing and length of the stationary line 1, 2, and insert them in your field-book: but in chaining from 1 to 2, stop at *d* opposite the angular point *a*, and in your field-book insert the distance from 1 to *d*, which admit to be 4 C. 25L. as well as the measure of the off-set *ad*, which admit to be 1C. 12L. thus: by the side of your field-book in a line with the first station, say at 4C. 25L. L. 1C. 12L. that is, at 4C. 25L. there is an off-set to the left hand of 1C. 12L.

This done, proceed on your distance line to *e* opposite to the angle *b*, and measure *eb*, supposing then 1 *e* to be 7C. 40L. and *eb* 3C. 40L. say (still in a line with the first station in your field-book) " at 7C. 40L. L. 3C. 40L." That is, at 7C. 40L. there is an off-set to the left of 3C. 40L. proceed then with your distance line to *f* opposite to the angle *c*, and measure *fc*; suppose then 1 *f* to be 13C. and *fc* 1C. 25L. say in the same line as before, at 13C. L. 1C. 25L. Then proceed from *f* to 2, and you will have the measure of the entire stationary line 1, 2, which insert in its proper column by the bearing.

In taking off-sets, it is necessary to have a perch chain, or a staff of half a perch, divided into links for measuring them; for by these means the chain in the stationary line is undisturbed, and the number of chains and links in that line from whence, or to which, the off-sets are taken, may be readily known.

Having arrived at the second station, if you find your view will carry you to 3, take the bearing from 2 to 3, and in measuring the distance line, stop at *l* opposite *g*; admit 2*l* to be 4C. 10L. and the off-set *lg* 1C. 20L. then in a line with the second station in your field-book, say at 4C. 10L. R. 1C. 20L. that is, the off-set is a right hand one of 1C. 20L. Again at *m*, which suppose to be 10C. 25L. from 2; take the off-set *mh* of 1C. 15L. and in a line with the second station, say at 10C. 25L. R. 1C. 15L. In the same line when you come to the boundary at *i*, insert the distance 2*i*, 13C. 10L. thus, at 13C. 10L. 0; that is, at 13C. 10L. there is no off-set. At *n*, which is 15C. from 2, take the off-set *nk* 45L. and still opposite to the second station say at 15C. L. 45. L.

Let the line, 3, 6, represent the boundary, which by means of water, briers, or any other impediment, cannot be measured. In this case make one or more stations within or without the land, where the distances may be measured, and draw a line from the beginning of the first to the end of the last distance, thus; make stations at 3, 4, and 5, taking the bearings, and measuring the distances as usual, which insert in your field-book, and draw a mark like one side of a parenthesis, from the third to the fifth station, to shew that a line drawn from the third station to the farthest end of the fifth stationary line will express the boundary. Thus,

No. Sta.	Deg.	Ch. L.
3	172½	5.45
4	200	13.25
4	250	3.36

Suppose the point *p* of the boundary to be inaccessible, by means of the lines 6*p* or *p*7, being overflowed, or that of a quarry, furze, &c. might prevent your taking their lengths: in this case take the bearing of the line 6, 7, which insert opposite to the sixth station in your field-book with the other bearing; then direct the index to the point *p*, and insert its bearings on the left side of the field-book, opposite to the sixth station, annexing thereto the words *Int. for boundary*; and having measured and inserted the distance 6, 7, set the index in the direction of the line 7*p*, and insert its bearing on the left of the seventh station of the field-book, annexing thereto the words *Int. for boundary:* the crossing or intersection of these two bearings will determine the point *p*, and of course the boundary 6*p*7 is also determined.

If your view will then reach in the first station,

take its bearing, stationary line, and off-sets, as before, and you have the field-book completed. Thus,

The Field-Book.

Remarks and intersect.	N. St.	Deg.	C. L.	OFF-SETS.
318 Int. to a tower	1	358	22.12	At 4 C. 25 L. L. 1C. 12L. at 7C. 40L. L. 3C. 40L. at 13C. L. 1C. 25L.
231½ Int. to ditto	2	297½	22.12	At 4C. 10L. R. 1C. 20L. at 10C. 25L. R. 1C. 51L. at 13C. 10L. 0. at 15C. L. 45L.
	3	172¼	5.45	
	4	200	13.25	
	5	250	3.36	
155½ Int. for bound.	6	125	15.15	At 1C. 20L. L. 2C. 20L. at 7C. 45L. L. 2C. 32L. at 11C. 25L. 0. at 12C. 25L. R. 36L.
274 Int. for ditto.	7	105¼	15.10	

Close at the first station.

If you would lay down a tower, house, or any other remarkable object in its proper place; from any two stations take bearings to the object, and their intersection will determine the place where you are to insert it, in the manner that the tower is set out in the figure, from the intersection taken at the first and second stations of the above field-book.

A protraction of this will render all plain, on which lay off all your off-sets and intersections, and proceed to find the content by any of the methods in section the 4th.

The foregoing field-book may be otherwise kept, thus,

Remarks and intersection.	No St.	Deg.	L. han. Off-set Ch. L.	Dist. Ch. L.	R. han. Off-set Ch. L.
318 Int. to a tower	1	358	1.12	4.25	
			3.40	7.40	
			1.25	13.00	
				22.12	
$232\frac{1}{2}$ Int. for ditto.	2	$297\frac{1}{2}$		4.10	1.20
				10.25	1.15
				13.10	
			0.45	15.00	
				21.21	
	3	$172\frac{1}{2}$		5.45	
	4	200		13.25	
	5	250		3.36	
$155\frac{1}{2}$ Int. for bound.	6	125		15.15	
274 In. for boundary.	7	105	2.20	1.20	
			2.32	7.45	
				11.25	
				12.25	0.36
				15.10	

How to cast up off-sets by the pen.

PL. 11. *fig.* 2.

$$1,2 - 1f = 2f - 1e = fe,\ 1e - 1d = ed.$$

Then $1d \times \frac{1}{2}da = 1da$, by prob. 6, page 183, and $\frac{1}{2}\,ed \times da + fe = bcfc$, and $2f \times \frac{1}{2}\,fc = cf9$; the sum

of all which will be 1*abc*21 ; the area contained between the stationary line 1, 2, and the boundary, 1 *abc* 2.

In the same manner you may find the area of 2*ihg*2, of *ik*3i, as well as what is without and withinside of the stationary line 7, 1.

If therefore the left hand off-sets exceed the right hand ones, it is plain, the excess must be added to the area within the stationary lines, but if the right hand off-sets exceed the left hand ones, the difference must be deducted from the said area; if the ground be kept on the right hand, as we have all along supposed; or in words, thus;

To find the contents of off-sets.

1. From the distance line, take the distance to the preceding off-set, and from that the distance of the one preceding it, &c. in four-pole chains; so will you have the respective distances from off-set to off-set, but in a retrograde order.

2. Multiply the last of these remainders by ½ the first off-set, the next by ½ the sum of the first and second, the next by half the sum of the second and third, the next by half the sum of the third and fourth, &c. The sum of these will be the area produced by the off-sets.

Thus, in the foregoing field-book, the first stationary line is 22C. 12L. or 11C. 12L. of four-pole chains. See the figure.

	Ch. L.	Ch. L.	Ch. L.
From	11.12=1,2	6.50=1*f*	3.90=1*e*
Take	6.50=1*f*	3.90=1*e*	2.25=1*d*
	4.62=2*f*	2.60=*ef*	1.65=*ed*

Ch. L.	
1*d*=2.25×32L. half the first off-set=	.7200
ed=1.65×1C. 26L. ½ the sum of the 1st and 2d	2.0790
ef=2.60×1C. 32L. ½ the sum of 2d and 3d=	3.4320
2*f*=4.62×37L. half the last off-set=	1.7094
Content of left off-sets on the first dist. in square four-pole chains	7.9404

In like manner the rest are performed.

The sum of the left hand off-sets will be	14.0856
And the sum of the right hand ones	3.6825
Excess of left hand off-sets in squ. 4 pole C.	10.4031
Acres	1.04031
	.16124
	4
Perches	6.4496

Excess of left hand off-sets above the right hand ones, 1A. 0R. 6P. to be added to the area within the stationary lines.

SECTION V.

To find the area of a piece of Ground by intersections only, when all the angles of the field can be seen from any two Stations on the outside of the ground.

Pl. 12. fig. 1.

LET *ABCDEFG* be a field, *H* and *I* two places on the outside of it, from whence an object at every angle of the field may be seen.

Take the bearing and distance between *H* and *I*, set that at the head of your field-book, as in the annexed one. Fix your instrument at *H*, from whence take the bearings of the several angular points *A*, *B*, *C*, *D*, &c. as they are here represented by the lines *HA*, *HB*, *HC*, *HD*, &c. Again fix your instrument at *I*, and take bearings to the same angular points, represented by the lines *IA*, *IB*, *IC*, *ID*, &c. and let the first bearings be entered in the second column, and the second bearings in the third column, of your field-book; then it is plain that the points of intersection, made from the bearings in the second and third columns of every line, will be the angular points of the field, or the points *A*, *B*, *C*, *D*, &c. which points being joined by right lines, will give the plan *ABCDEFGHA* required.

Bear. 180 Dis. 28C. of the Sta. H and I.

No.	Bear.	Bear.
A	261½	331½
B	265¾	317¼
C	248	307½
D	238¼	289
E	215½	262½
F	208½	286½
G	220	300

The same may be done from any two stations within-side of the land, from whence all the angles of the field can be seen.

This method will be found useful in case the stationary distances from any cause prove inaccessible, or should it be required to be done by one party, when the other in whose possession it is, refuses to admit you to go on the land.

To find the content of a field by calculation, which was taken by intersection.

In the triangle *AIH*, the angles *AHI*, *AIH*, and the base *HI* being known, the perpendicular *Aa*, and the segments of the base *Ha*, *AI* may be obtained by trigonometry: and in the same manner all the other perpendiculars *Bb*, *Cc*, *Dd*, *Ee*, *Ff*, *Gg*, and the several segments at *b*, *c*, *d*, *e*, *f*, and *g*: if therefore the several perpendiculars be supposed to be drawn into the scheme (which are here omitted to prevent confusion arising from a multiplicity of lines) it is plain that if from *bBCDEeb*, there be taken *bBAGFeb*, the remainder will be the map *ABCDEFGA*.

As before half the sum of *Bb*, and *Cc* multiplied by *bc*, will be the area of the trapezium *bBCc*; after the same manner, half the sum of *Cc*, and *Dd*, multiplied by *cd*, will give the area of the trapezium *cCDd*; and again, half the sum of *Dd*, and *Ee* multiplied by *de*, gives the area of the trapezium *dDEe*; and the sum of these three trapezia will be the area of the figure *bBCDeb*.

Again, in the same manner, half the sum of *Bb* and *Aa* multiplied by *ah*, will give the area of the trapezium *BbAa*; and half the sum of *aA*, and *gG*, by *ag*, gives the trapezium *aAGg*; to these add the trapezia *gGFf*, and *fFEe*, which are found in the like manner; and you will have the figure *bBAGFEeb*, and this taken from *bBCDeb*, will leave the map *ABCDEFGA*. *Q. E. F.*

It will be sufficient to protract this kind of work, and from the map to determine the area as well as in plate 10. fig. 3. to find the areas of the pieces, 3, 4, 5, 6, 3, and 6, 7, 7, 6, from geometrical constructions.

How to determine the station where a fault has been committed in a field book, without the trouble of going round the whole ground a second time.

From every fourth or fifth station, if they be not very long ones, or oftener if they are, let an intersection be taken to any object, as to any particular part of a castle, house, or cock of hay, &c. or if all these be wanting, to a long staff with a white sheet or napkin set thereon, to render the object more conspicuous, and let this be placed on the summit of the land, and let the respective intersections so

taken be inserted on the left hand side of the field-book, opposite to the stations from whence they were respectively taken.

In your protraction as you proceed, let every intersection be laid off from the respective stations from whence they were taken, and let these lines be continued; if they all converge or meet in one point, we thence conclude all is right, or so far as they do converge; but if we find a line of intersection to diverge or fly off from the rest, we may be sure that either a mistake has happened between the station the foregoing intersection was taken at, and the station from whence the intersection line diverges, or there must be an error in the intersection; but to be assured in which of these the fault is, protract on to the next intersection, and having set it off, if it converges with the rest, though the foregoing one did not, we may conclude the fault was committed in taking the last intersection but one, and none in any station, and that so far is true as is protracted; but if this as well as the foregoing intersection diverge or fly from the point of concourse or converging point of the rest, the error must have its rise from some station or stations, at or after that, from whence the last converging intersection line was taken: so that by going to that station on the ground, and proceeding on to that where the next, or from whence the following diverging intersection was taken, we can readily and with little trouble set all to rights.

But in most tracts of land, one object cannot be seen from every station, or from perhaps one fourth of them; in this case we are under the necessity to move the pole after we begin to lose sight of it, to some other part of the land, where

it may be seen from as many more stations as possible; which is easily done by viewing the boundary before it be surveyed: the pole then being fixed in an advantageous place, the first intersection to it is best to be made from the same station from whence the last one was taken, and then as often as may be thought convenient, as before; in like manner the whole may be done by the removal of the pole.

When we here speak of stations, we do not mean such as are usually taken at every particular angle of the field: for it is to be apprehended, that every skilful surveyor, particularly such who use calculation, will take the longest distances possible, not only to lessen the number of stations, for the ease of either protraction or calculation, but with greater certainty to account for the land passed by, on the right hand or on the left, which is taken by off-sets: and surely it will be allowed that any measure taken on the ground, and the content thence arithmetically computed, will be much more accurate than that which is obtained from any geometrical projection.

From what has been said it is plain, that from this method any fault committed in a survey can be readily determined, and therefore must be much preferable to the present method of taking diagonals, or the bearings and lengths of lines across land, to accomplish that end; which last method is too frequently used by surveyors to approximate or arrive near the content, which will ever remain uncertain, let these diagonals be ever so many, till the station or stations wherein the error or errors were committed, be found; and the fault or faults be corrected.

Where one diagonal is taken, it may perhaps close or meet with one part of the survey and not with the other; in this case, if the surveyor would discover his error, he must survey that part of the land which did not close, and this may be half or more, of the whole. And should the diagonal close with neither part, but be too long, or too short, or should it fall on either side of the assigned point it was to close with, he ought to go over the whole, and make a new survey of it in order to discover his error.

A number of diagonals are frequently taken, the sum of the lengths of which very often exceeds the circuit of the ground, and after all they are but approximations, and the content remains uncertain as before; therefore he who returns a map, made up by the assistance of diagonals, where there remains a misclosure in any one part, runs the risque of being detected in an error, and must suffer uneasiness in his mind, as he cannot be certain of the return he makes.

The frequent misclosures which are botched up by diagonals, occasion the many and frequent scandalous broils and animosities between surveyors, which tend to the loss of character of the one or the other, and indeed often to the disrepute of both, as well as to that of the science they profess.

But these may be easily remedied by intersections, and the bearing or line to be adjusted where the fault was committed, and till this be found, nothing can be certain.

SECTION VI.

To enlarge or diminish maps.

To enlarge or diminish a map, or to reduce a map from one scale to another; also the manner of uniting separate maps of lands which join each other, into one Map of any assigned size.

LAY the map you would enlarge, over the paper on which you would enlarge it, and with a fine protracting pin, prick through every angular point of your map, join these points on your paper (laying the map you copy before you) by pencilled or popped lines, and you have the copy of the map you are to enlarge: in this manner any protractiom may be copied on paper, vellum, or parchment, for a fair map.

If you would enlarge a map to a scale which is double, or treble, or quadruple to that of the map to be enlarged, the paper you must provide for its enlargement must be two, or three, or four times as long and broad as the map; for which purpose in large things you will find it necessary to join several sheets of paper, and to cement them with white wafer or paste, but the former is best,

Then pitch upon any point in your copied map for a centre; from whence if distances be taken to its extreme points, and thence if those distances be set in a right line with (but from) the centre,

and these last points fall within your paper, the map may be increased on it to a scale as large again as its own; and if the like distances be again set outwards in right lines from the centre, and if these last points fall within your paper, it will contain a map increased to a scale three times as large as its own, &c.

Pl. 12. *fig.* 2.

Let the pricked or popped lines represent the copy of a down or old survey, laid down by a scale of 80 perches to an inch, and let it be required to enlarge it to one laid down by 40 to an inch.

Pitch upon your centre as ⊙, from whence thro' *a* lay the fiducial edge of a thin ruler, with a fine pointed pair of compasses, take the distance from *a* to the centre ⊙, and lay it by the ruler's edge from *a* to *A*: in the like manner take the distance from the next station *b* to the centre ⊙, and lay it over in a right line from *b* to *B*, and join the points *A* and *B* by the right line *AB*; in the like manner set over the distance from every station to the centre, from that station outwards, and you will have every point to enlarge to; the joining of these constantly as you go on by right lines, will give you the enlarged map required.

In taking the distance from every station to the centre, set one foot of the compasses in the station, and the other very lightly over the centre-point, so lightly as scarcely to touch it, otherwise the centre-point will become so wide, that it may occasion several errors in the enlarged map: for

if you err from the exact centre but a little, that error will become double, or treble, or quadruple, as you enlarge to a scale that is double, or treble, or quadruple of the given one; therefore great accuracy is required in enlarging a map.

When you have done with a station, give a dash with a pen or pencil to it, such as at the station *a* and *b*; by this means you cannot be disappointed in missing a station, or in laying your ruler over one station twice.

From what has been said it is plain, that if a map is to be enlarged to one whose scale is double the given one, that the distances from the respective stations to the centre, being set over by the ruler's edge, will give the points for the enlarged one. And thus may a map be enlarged from a scale of 160 to one of 80, from one of 80 to one of 40, from one of 20 to one of 10 perches to an inch, &c. For to enlarge to a scale that is double, the number of perches to an inch for the enlarged map must be half of those to an inch for that to be enlarged: to enlarge to a scale that is treble the given one, the number of perches to an inch for the enlarged map, will be one third of those for the other; if to a scale that is quadruple the given one, the number of perches to an inch for the enlarged map, will be one fourth of those for the other, &c. therefore if you would enlarge a map which is laid down by a scale of 120 perches to an inch, to one of 40 perches to an inch, the distance from the several stations to the centre, being set twice beyond the said stations, will mark out the several points required, for these points will be three times further from the centre than the stationary points of the map are.

In the same manner, if you would enlarge a map from a scale of 160, to one of 40 perches to an inch, the distance from the several stations to the centre, being set three times beyond said stations, will lay out the points for your enlarged map, for these points will be four times further from the centre than are the stations of the map.

When a map is enlarged to another, whose scale is double, or treble, or quadruple, &c. of the given one, every line, as well as the length and breadth of the enlarged map, will be double, or treble, or quadruple, &c. those of the given one, for it must be easy to conceive that those maps are like: but the area, if the scale be double, will be four times; if treble, nine times; if quadruple, sixteen times that of the given figure; that is, it will contain four, nine, or sixteen times as many square inches as the given one (for it has been shewn that like polygons are in a duplicate proportion with the homologous sides). Yet these figures being cast up by their respective scales will produce the same content.

Thus much is sufficient for enlarging maps, and from hence, diminishing of them will be obvious; for one fourth, one third, or half the distances from the several stations to the centre, will mark out points, which if joined, will compose a map similar to the given one, whose scale will be four times, three times, or twice as small as the given one.

Thus, if we would reduce a map from 40 to 80, from 20 to 40, from 10 to 20 perches to an inch, &c. half the distance of the stations from the centre will give the points requisite for drawing the

map; if we would reduce from 40 to 120, from 20 to 60, from 10 to 30 perches to an inch, &c. one third of the distances to the centre, will give the points for the map; and if we would reduce from 40 to 160, from 20 to 80, from 10 to 40 perches to an inch, &c. one fourth of the distances to the centre, will give the points for the map.

By the methods here laid down I have reduced a map from a scale of 40 to one of 20 perches to an inch, which contained upwards of 1200 acres, and consisted of 1224 separate divisions, without the least confusion from the lines; for none can arise if the methods here laid down be strictly observed.

I have also from the same methods reduced a large book of maps, each of which was an entire skin of parchment, and the whole contained upwards of 46000 acres, to a pocket volume; and afterwards connected all these maps into one map, which was contained in one skin of parchment: therefore upon the whole I do recommend these methods for reducing maps to be much more accurate than any of the methods commonly used, such as squaring of paper, using a parallelogram, proportionable compasses, or any other method I ever met with, though the figures to be reduced were ever so numerous, irregular, or complicated.

To unite separate maps of lands which join each other, into one map of any assigned size.

If there be several large maps contained in a book, each of which suppose to take up a skin

of parchment, or a sheet of the largest paper; which maps of lands join each other; and it be required to reduce them to so small a scale, that all of them when joined together may be contained in one skin, half a skin, or any assigned sized piece of parchment, or paper.

Having pricked off and copied the several maps on any kind of paper, unite them by cutting with scissors along the edge of one boundary which is adjoining the other, but not cutting by the edge of both, and throw aside the parts cut off; then lay these together on a large table, or on the floor, and where the boundaries agree, they will fit in with each other as indentures do; and after this manner they are easily connected: measure then the length and breadth of the entire connected maps, and the length and breadth of the parchment or paper you are confined to; if the former be three, four, or five times greater (that is, longer and broader) than the latter, reduce each copied map severally to a scale that is three, or four, or five times less, as before; and the same parts of the boundaries you cut by in the large maps, by the same you must, also cut in small ones, and unite the small as the large ones were united; cementing them together with white wafer: thus will your map be reduced to the assigned size, which copy over fair, on the parchment, or paper you were confined to.

But it is not always that a person is confined to a given area of parchment, or paper; in such cases, if there are many large maps to be united into one, reduce each of them severally to a scale of 160 perches to an inch, and unite those by the contiguity or boundaries, as before: or if you have

a few, it will be sufficient to reduce them to a scale of 120, *&c.* But having the maps given, and the scale by which they are laid down, your reason will be sufficient to direct you to know what scale they should be reduced to.

Directions concerning surveys in general.

If you have a large quantity of ground to survey, which consists of many fields or holdings, and that it be required to map and give the respective contents of the same, it is best to make a survey of the whole first, and to be satisfied that it is truly taken, as well as to find its content; and as you go round the land, to make a note on the side of your field-book at every station where the boundary of any particular field or holding intersects or meets the surround; then proceed from any one of those stations, and in your field-book say, "proceed from such a station," and when you have gone round that field or division, insert the station you close at, and so through the whole: a little practice can only render this sufficiently familiar, and the method of protraction must be evident from the field-notes. When the whole is protracted, and you are satisfied of the closes of the particular divisions, cast up each severally, and if the sum of their contents be equal to the content of the whole first found, you may safely conclude that all is right.

The protraction being thus finished and cast up, transfer it on clean paper, vellum, or parchment, as before; be careful to draw your lines with a fine pen, write on it the names of the circumjacent lands, and set No. 1, 2, 3, 4, *&c.* in every parti-

cular field or division; let every tenant's particular holding be distinguished by a different coloured paint being run finely along the boundaries; let all the roads, rivulets, rivers, bridges, bogs, ponds, houses, castles, churches, beacons (or whatever else may be remarkable on the ground) be distinguished on the map. Write the title of the map in a neat compartment either drawn, or done from a good copper-plate graving, with the gentleman's arms. Prick off one of your parallels with the map, and on it make a mariner's compass, and draw a flower-de-luce to the north, and this will represent the magnetical north; after which set off the variation, which express in figures, and through the centre of the compass, let a true meridian line be drawn of about 3 inches long, by which write True Meridian. Let a scale be drawn, or it is sufficient to express the number of perches to an inch, the map was laid down by. Draw a reference table of three, or, if occasion be, of four or more columns; in the first insert the number of the field or holding: in the next its name, and by whom occupied: in the third the quantity of acres, roods, and perches it contains: if you have unprofitable land, as bog or mountain, let the quantity be inserted in the fourth column; and, if it be required, you may make another column for statute measure, and then the map is completed.

SECTION VII.

THE METHOD OF DIVIDING LAND, OR OF TAKING OFF OR INCLOSING ANY GIVEN QUANTITY.

EXAMPLE I.

Pl. 12. *fig.* 1.

Let *ABCD, &c.* be a map of ground, containing 11 acres, it is required to cut off a piece as *DEFGID*, that shall contain 5 acres.

Join any two opposite stations as *D* and *G*, with the line *DG*, (which you may nearly judge to be the partition line) and find the area of the part *DEFG*, which suppose may want 3R. 20P. of the quantity you would cut off: measure the line *DG*, which suppose to be 70 perches. Divide 3R. 20P. or 140P. by 25, the ½ of *DG*, and the quotient 4 will be a perpendicular for a triangle whose base is 70, and the area 140P. Let *HI* be drawn parallel to *DG*, at the distance of the perpendicular 4, and from *I*, where it cuts the boundary, draw a line to *D*, and that line *DI*, will be the division line; or a line from *G* to *H* will have the same effect; all which must be evident from what has been already said.

But if hills, trees &c. obstruct the view of the points *D* and *I* from each other, it will be necessary in order to run a partition line, to know its bearing; and it may be proper on some occasions, to have its length; both these may be easily calculated from the common field-notes only, as in the following example, without the trouble of any other measurement on the ground, or any dependance on the map and scale.

EXAMPLE II.

Pl. 12. *fig.* 3.

Let *ABCDEFGHIA* be a tract of land, to be divided into two equal parts, by a right line from the corner *I* to the opposite boundary *CD*; required the bearing and length of the partition line *IN*, by calculation, from the following field-notes, *viz.*

Field-Notes and Area.		
Boun.	Bearing.	Perch.
AB	N. 19°. 0′ E.	108.
BC	S. 77. 0 E.	91.
CD	S. 27. 0 E.	115.
DE	S. 52. 0W.	58.
EF	S. 15. 30E.	76.
FG	West.	70.9
GH	N. 36. 0W.	47.
HI	North.	64.3
IA	N. 62. 15W.	59.
	152A. 1R. 25.9P.	

Operation.

IABCI		Per.	N.	S.	E.	W.	Merid dist. &c.
IA	N. 62°¼ W.	59	27.5	——	——	52.2	
AB	N. 19 E.	188	102.1	——	35.2	——	
BC	S. 77 E.	91	——	20.5	88.7	——	
CI	——	——	——	109.1	——	71.7	
Area, 8722.3 perches			129.6	129.6	123.9	123.9	

152A. 1R. 25.9P. = 24385.9 perch.

half, to be divided off, = 12192.9 } subt.
the part *IABCI* = 8722.3 }

Triangle *ICNI* = 3470.6 perches.

ICDI.		Per.	N.	S.	E.	W.	Merid. dist. &c.
IC	N.——E.	115	109.1	——	71.7	——	
CD	S. 27. E.	——	——	102.5	52.2	——	
DI				6.6	——	123.9	
Area, 6522.1 per.			109.1	109.1	122.9	123.9	

Then, as $\left\{ \begin{array}{l} ICDI : CD :: ICNI : CN \\ 6522.1 : 115 :: 3470.6 : 61.19 \end{array} \right\}$ Th. 18 Sec. 1

which determines the point *N* in *CD*.

ICNI.		Per.	N.	S.	E.	W.
IC	as before	—	109.1	——	17.7	
CN	S. 27 E.	61.2	——	54.6	27.8	——
NI			——	——	——	——
		——	——	54.6	——	99.5

As dif. lat. 54.6		As S. Bear	61°15′
: Radius	S. 90 deg.	: Depart.	99.5
: : Depart.	99.5	: : Radius S.	90 deg.
: Tang. Bear.	61°15′	: Distance	113.49

Answer, $\left\{ \begin{array}{l} IN \text{ runs N. } 61°15' \text{ E.} \\ NI \text{ runs S. } 61\ 15 \text{ W.} \end{array} \right\}$ 113.5 per.

In the part *IABCI*, the difference between the northings and the southings of the three lines, *IA*, *AB* and *BC* (109.1) is the difference of latitude, and that of their eastings and westings (71.7) the departure of the line *CI*, which is placed thereto, so as to balance the columns; see theo. 1. sect. 5. hence the content is obtained, as already taught, without the bearing or length of the line *CI*.

For the triangle *ICDI*, the diff. lat. and dep. of *IC* are taken from the preceding table, which in going from *I* to *C* will be northing and easting: those of *CD* are found by the bearing and distance, and of *DI* by balancing the columns, as before for *CI*.

The difference of latitude (54.6) and departure (99.5) of the line *NI*, in the third table, are found by balancing those of *IC* and *CN*; and as they are the base and perpendicular of a right angled triangle, of which the line *NI* is the hypothenuse, and the angle opposite to the departure, the bearing, we have the answer by two trigonometrical statings, as above; and thus may any tract be accurately divided, or any proposed quantity readily cut off or inclosed.

Now the student or practitioner may calculate the content of the part *ABCNIA* (the bearing and distance, or the diff. lat. and dep. of *CN* and of *NI* being known) and if it be found equal to the intended quantity, it proves the truth of the operation.

Example III.

Pl. 12. *fig*. 3.

It is proposed to cut off 38A. 16P$\frac{1}{4}$. to the south end of this tract, by a line running from *E* due West 40 perches to a well at *O*, and from thence a right line to a point *M* in the boundary *HI*; the place of *M*, and the bearing and length of the line *OM* are required; the field-notes being as in example 2d.

Answer, $\left\{ \begin{array}{l} M \text{ from } H, \text{ north, } 43.23 \\ OM, \text{ N. } 78^\circ 7' \text{ W. } 39.03 \end{array} \right\}$ perches.

In this example we find,

		Perches.
The area of	$OEFGHO =$	5270.5
Consequently of	$HOMH =$	826.0
Dif. lat. of the line	$HO = HV =$	35.2
Departure of ditto	$= QV =$	38.2

As HI happens to be a meridian, the area of $HOMH$ divided by half OV (19.1) quotes HM (43.23) without finding the area of $HOIH$, as we did of $ICDI$ in example 2d. and $HM - HV = VM = 8.03 =$ dif. lat. of OM, which with its dep. $VO = 38.2$. gives the bearing and distance as before.

Example IV.

Pl. 12. *fig.* 4.

A trapezoidal field $ABCD$, bounded as under specified, is to be divided into two equal parts by a right line EF parallel to AB or CD; required AF or BF?

Bou.	Bearing.	Per.
AB	South.	30.
BC	N. 80 W.	60.
CD	N. 39½ W.	45.5
DA	S. 80 E.	89.4
	13A. 3R. 7P.	

In the triangle CBG are given BC and all the angles (known by the bearings) to find BG, and thence the area by prob. 9. sect. 4. which + half the area of $ABCD$ = area of EFG; then as the area of CBG to that of EFG, so is the square of BG to the square of FG, and $FG - BG = BF$.

Operation at large.

Angle *G* 39° 30′, log. S. Co. Ar.	0.19649	
Side *BC* 60 per. log.	1.77815	add
Angle *C* 40° 30′, sine	9.81254	
Side *BG* 61.26 per.	1.78718	
Side *BC* 60 per.	1.77815	add
Angle *B* 100° 0′, sine	9.99335	
2)3619.8, log.	3.55868	
As *CBG* = 1809.9 Co. Ar.	6.74235	
1103.5 = *BCEF*		
To *EFG* = 2913.4, log.	3.46440	add
So sqr. *BG* 61.26, log.	1.78718	
	1.78718	
To sqr. *FG* 77.72	(2)3.78111	
Ans. *BF* = 16.46 per.	1.89055	

By the application of this method a tract of land may be divided accurately, in any proportion, by a line running in any assigned direction.

Note. When the practitioner would wish to be very accurate, it will be much better to work by four-pole chains and links than by perches and tenths; one tenth of a perch square being equal to 6¼ square links.

EXAMPLE V.

The following Field-Notes (from A. Burns) *are of a piece of land, which is proposed, as an example, to be divided into three equal parts by two right-lines running from the sixth and seventh stations; and proved, by calculating the content of the middle part.*

St.	Bearing.		4P. C.
1	N.E.	56°¼	21.60
2	N.E.	26½	13.44
3	S.E.	71½	18.96
4	S.E.	26½	13.44
5	S.W.	71½	18.96
6	S.E.	45	8.47
7	S.E.	63½	13.44
8	N.E.	45	8.47
9	S.E.	26½	13.44
10	S.W.	45	8.47
11	S.W.	63½	13.44
12	N.W.	76	24.73
13	N.W.	36¾	30.00
	A.	R.	P.
Area	167	1.	24.

Example VI.

Pl. 8. *fig.* 5.

The plot *ABCDEFGHA* is proposed to be divided, *geometrically*, in the proportion of 2 to 3, by a right line from a given point in any boundary or angle thereof, suppose the point *D*.

Reduce the plot to the triangle *cDe*, as already taught; divide the base *ce* in the point *N*, so that *eN* be to *Nc* in the ratio of two or three, by prob. 14. page 53; draw *DN*, and it is done.

Example VII.

Pl. 12. *fig.* 3.

Example 2d may likewise be performed geometrically.

Produce *CD* both ways for a base, and reduce the whole to a triangle, making *I* the vertical point; then bisect the base in *N*, and draw *IN*. But,

Notwithstanding this geometrical method is demonstrably true in theory, it is not as safe, on practical occasions requiring accuracy, as the calculation, even when performed with the greatest care; for which reason we will not enlarge on it here.

Example VIII.

Suppose 864 acres to be laid out in form of a right-angled parallelogram, of which the sides shall be in proportion as 5 to 3; required their dimensions?

For the greater side, multiply the area by the greater number of the given proportion, and divide

by the less, or, for the less side, multiply by the less number, and divide by the greater; the square root of the quotient will be the side required: thus,

864A.=138240P	1.38240
5	3
3)691200	5)414720
Answ. $\surd$ 230400=480.	$\surd$ 82944=288.

Example IX.

If it be required to lay out any quantity of ground, suppose 47A. 2R. 16P. in form of a parallelogram, of which the length is to exceed the breadth by a given difference, for instance 80 perches, then add the square of half this difference to the area; and take the square-root of the sum; to which add half the difference for the greater side, and subtract it therefrom for the less; thus,

2)80	47A. 2R. 16P.=7616 perches.
40	1600
40	$\surd$ 9216=96
1600 half diff.	add and subt.—40

$$\text{Ans.}\begin{cases}\text{the length} = 136\\ \text{the breadth} = 56\end{cases}$$

Any proposed quantity of ground may be laid out or inclosed in the form

of a	Square - -	by prob. 2d.	sec. 4.
	Parallelogram, 1 side giv.	by pro. 4th.	
	Triangle of a given base,	by pro. 7th.	
	Circle - -	by prob. 13th.	

It is sometimes most convenient, when land is to be laid out adjacent to a creek, river, or other crooked boundary, to measure off-sets to the angles or bending thereof, from a right line or lines taken near such boundary, and to deduct the area of these off-sets from the given quantity, and then to lay off the remainder from the right-line or lines, in the desired form.

In laying out new lands, attention must be paid to the allowance for roads, as exemplified in prob. 14th.

Example x.

It is required to divide off 30 acres, to the south east end of the tract, of which the field-notes are given in example 4th, by a right-line to run N. 20° E. See example 4th.

SECTION VIII.

OF SURVEYING HARBOURS, SHOALS, SANDS, &c.

Pl. 13. *fig.* 1.

THERE are three methods whereby this may be performed; for the observations may be made either on the water or on the land. Those made on the water are of two kinds, one by the log-line and compass (as in plane sailing measuring) the course and distance round the sand; and then to be plotted as a large wood, or any inclosure taken by the circumferentor.

This method I omit for two reasons; first, because it is to be deduced from the writers of navigation: and, secondly, because the distances thus measured are liable to the errors of currents, which generally attend shoals or sands near the shore.

The second method, where there are no distances to be measured on the water, though still there is one inconvenience, common also to the former, because the bearings or observations are to be taken on that unstable element (an error scarce mentioned by practical artists) I shall briefly hint at; and so rather choose a third, which is liable to neither of these imperfections.

Let a boat be manned out with a signal flag, a log and line, lead and line, and to observe the bearings of any land mark, a compass with sights.

Take two or more objects or places, as *A*, *B*, *C*, on the shore, from whence the boat may be seen on the several parts of this shoal, and determine their relative position by bearing and distances either before or after the other necessary observations are made.

One of the boat's crew is to sound till he finds himself on the edge of the sand, by the depth of water, and then to come to an anchor; which he is to signify to two persons on the shore, at *B* and *C*, by his signal. And then from those known land-marks, *B* and *C*, the observers are to take the bearings of the boat, and to register their observations; which, when done, they are to signify to the crew by waving a flag, or by some other signal.

And in the mean time, to prevent mistakes, let the crew take the bearings of each of these land-marks: then weigh anchor, which suppose at *D*.

Then by sounding, proceed to *E*, and make like observations. And so at *E*, *F*, *G*, &c. till you have surrounded your sand.

And if in this process, you are about to lose the sight of one of your land-marks, suppose *C*, let your assistant at *C*, or *B*, who at that time will also be about to lose the sight of the boat, by signals (before agreed on) remove to some other object before-hand agreed on, suppose to *H*, or *K*; and then to proceed as before.

Lastly, if the sand runs so far out at sea, that the object cannot be seen by the boat, nor the boat by the observer on shore; there may be rockets fired by the boat's crew, and also by the observers on the shore in the night, whereby those bearings may be taken almost at as great a distance as the light can be seen. For supposing they rise but a quarter of a mile above the apparent horizon, its stay will be about 9 seconds, and its distance for this quarter of a mile will be visible about 44 miles.

But rockets rise much higher, and then the distances are much greater, whereby they are visible.

Or two boats may lay at anchor instead of the land marks, and then you may work as before.

Now, since the land-marks *B* and *C* are fixed, their position may be laid down in the draught, as in common surveying, by plotting the distance between *B* and *C*. And then by plotting the line *BD*, and the line *DC*, according to their position, their common intersection will give the point *D*. And in like manner *E*, *F*, *G*, &c. may be plotted; and so the shoals completed. And this from the bearings taken at *B* and *C*.

If this be a standing lake, environed by bogs, or other impediments, the observations at *D*, *E*, *F*, &c. by taking their opposites, may suffice to plot the same from the land-mark, *A*, *B*, *C*, &c. as well as those taken on the land: or, indeed, by the course and distance, as in navigation, if the water be smooth and without a current.

In sea shoals, it is convenient to note at each observation the depth of the water found by the lead, and the drift and setting of the current by the log and compass, while the boat is at anchor, which may be done with ease and expedition enough. For, while the boat rides at an anchor, her stern points out the setting of the current, and the log and glass will measure its drift.

And these ought to be noted on the draught, which may be thus:

The currents may be shewn, by drawing a dart pointing out its setting, and its drift by the Roman capital letters, the depth of the water by the small figures, and rocks by little crosses, &c.

SECTION IX.

LEVELLING.

Pl. 13. *fig.* 2.

LEVELLING is the art of ascertaining the perpendicular ascent or descent of one place (or more) above or below the horizontal level of another, for various intentions; and of marking out courses for conveyance of water, &c.

The *true level* is a curve conforming to the surface of the earth; as *ABG*.

The *apparent level* is a tangent to that curve; as *ADE*.

The *correction*, or allowance for the earth's curvature, is the difference between the apparent level and the true, as *BD*. The quantity of this correction may be known by having, in the right-angled triangle *CAB*, the two legs, *AC*=the semidiameter of the earth (=1267500 perches) and *AD*=the distance of the object, to find the hypothenuse *CD*, from which taking *CB* (=*CA*) the remainder will be the correction *BD*; but it may be obtained more practically thus;

Square the distance in
four-pole chains, and divide by 800,
or in perches, and divide by 12800,
or in miles, and multiply by 8;
for the correction in inches.

EXAMPLE.

Required the correction for 20 four-pole chains =80 perches=$\frac{1}{4}$ mile.

$$800)20\times20=400(.5$$
$$12800)80\times80=6400(.5$$
$$\tfrac{1}{4}=.25\text{, and } .25\times.25\times8=.5$$

that is, .5, or $\frac{1}{2}$ inch, the correction required.

But, to save the trouble of calculation, we insert the following table of corrections.

A Table of Corrections.

The distances in four-pole chains.

Distan.	Correc.	Distan.	Corre.
Chains	Inches	Chains.	Inches
1	0,0012	27	0,91
2	0,005	28	0,98
3	0,01125	29	1,05
4	0,02	30	1,12
5	0,03	31	1,19
6	0,04	32	1,27
7	0,06	33	1,35
8	0,08	34	1,44
9	0,10	35	1,53
10	0,12	36	1,62
11	0,15	37	1,71
12	0,18	38	1,80
13	0,21	39	1,91
14	0,24	40	2,00
15	0,28	45	2,28
16	0,32	50	3,12
17	0,36	55	3,78
18	0,40	60	4,50
19	0,45	65	5,31
20	0,50	70	6,12
21	0,55	75	7,03
22	0,60	80	8,00
23	0,67	85	9,03
24	0,72	90	10,12
25	0,78	95	11,28
26	0,84	100	12,50

The first thing necessary in levelling, is the adjusting of the level, which may be performed several ways; The following is very easy and practical.

Choose some ground which is not above 4 or 5 feet out of the level, for the distance of 8 or 10 chains length, and suppose it be *AB* (fig. 3.) and find the middle between *A* and *B*, which suppose to be *C*; plant the instrument at *C*: direct the tube to a station-staff, held up at *A*, and elevate or

depress the tube, till the bubble is exactly in the middle of the divisions; then by signals direct your assistant at *A*, to rise or depress the vane, sliding on the station staff, till the horizontal hair in the glass cuts the middle of that vane: then see how many feet, inches, and parts, are cut by the upper part of the vane, which suppose to be 3 feet 4 inches and 6 tenths.

In like manner direct to the other staff at *B*, and suppose the upper edge of that vane to cut at the height of 6 feet, 5 inches and two tenths, then will these two vanes be on a level.

From 6 feet 5.2 inches subtract 3 feet 4.6 inches, and reserve the remainder 3 feet 0.6 inches.

Now, remove the instrument as close to the higher station-staff as you can; so that the middle of the telescope may almost touch it. Then bring the telescope as near to a level as the judgment of the eye will direct.

Measure from the ground, the height of the top of the telescope; and also of the bottom, in feet, inches, and parts; suppose them to be 4 feet, 10.5 inches, and 5 feet 0.3 inches; then half the sum of the heights 4 feet 11.4 inches is the height of the centre of the glass; and to this add half the breadth of the vane, which suppose to be 1 inch and 5 tenths, and to the sum 5 feet 0.9 inches, add the preceding remainder 3 feet 0.6 inches; then let the person at *B* move his vane, till the upper edge cut 8 feet 1.5 inches, the sum of the preceding numbers.

Now, so elevate or depress the hair or the bubble, till the hair cut the middle of the vane at B, and at the same time the bubble stands at the middle of the divisions; and then will the instrument be duly adjusted.

If you have a mind to be more accurate, repeat the operation; but when you place the instrument at *C*, turn the tube at right angles to the line *AB*, and there set it level; then proceed with a repetition of the work. Only observe to cross-level it in this adjustment, and in all future uses whatsoever.

Or the level may be adjusted thus: As before, first plant the instrument in the middle between *A* and *B* (fig. 4.) and observe the heights on the station-staves, which suppose to be as above; and consequently their difference, as before, is 3 feet 0.6 inches. Now measure from *C* towards the highest ground *A*, some distance that comes almost to *A*; suppose 4 chains to *D*, and *DB* will be 6 chains, and *DA* one chain: Then plant the instrument at *D*, direct the telescope to *A*, and setting the bubble to the middle of the division, direct your assistant to move the vane, till the hair cuts the middle of it; and note down the feet, inches, and parts cut by the upper edge of the vane; which suppose to be 3 feet 8.4 inches. To this add the difference 3 feet 0.6 inches, and the sum 6 feet 9 inches reserve.

Now direct the telescope to the staff at *B*, level it, and direct your assistant to move the vane, till the hair cuts the middle thereof; and then, if the upper edge of the vane cuts the foregoing sum 6 feet 9 inches, the hair and bubble are truly adjust-

ed. But if not, say, As *BD* less *AD*, is to the difference between the numbers cut by the upper edge of the vane, and the number 6 feet 9 inches; so is the distance *AD* to a number, which added to that cut by the vane, when less than 6 feet 9, and subtracted from the number cut by the vane, when it is greater than 6 feet 9, will give a number to which let the assistant fix the vane; then so elevate or depress the hair or the bubble, till the hair cuts the middle of the vane at *B*, and the bubble stands in the middle of the divisions; for then the level will be adjusted. The operation may be again repeated, and at every station cross levelled, which will confirm the former adjustment.

Or it will be still better to set the station staves equally distant from the instrument (suppose about 16 or 20 perches each) at an angle of about 60°, or so as to form nearly an equilateral triangle therewith, and level the 2 vanes (*A* and *B* fig. 5.) as before, which will be then both in the same horizontal level, whether the instrument be right adjusted or not, because one will be as much above or below the true level of the instrument, as the other, being in the same distance from it; then remove the instrument as near as may be to one of them, suppose *A*, and raise or lower the vane *A* to the exact level of the visual ray in the instrument, noting precisely how much it is moved, and have the other vane *B* move just as much, in order to bring them again to a level, allowing for the correction of the apparent level if it be a sensible quantity; then adjust the instrument to the level of the vane at *B*.

To adjust the rafter level (plate 13. fig. 6.) which may be 10, 12, or 14 feet in the span *AB*; set it on a plank or hard ground nearly level, and mark

where the plumb line cuts the beam *mn*, suppose at *c*, then invert the position by setting the foot *A* in the place of *B*, and *B* in that of *A*, marking where the line now cuts, as at *e*; the middle point between *c* and *e* will be the true levelling mark.

To continue a level course with this instrument, set the foot *A* to the starting place, and move *B* upward or downward toward *D* or *E*, till the point *B* be determined and marked for a level with *A*, then carry the instrument forward in the direction of *C* till the foot *A* rests at *B*, whence the point *C* is levelled as before, &c. Sights may be placed at *r* and *s*, and the instrument adjusted to them, as before, by reversing them in the direction of some distant object.

After the instrument is duly adjusted, you may proceed to use it. Let the example be this annexed (fig. 7.) where *A* every where represents the level, and *B* the station staves; and suppose the route be made from *a* to *e*; first plant the instrument between the staves *a* and *b*: at *A* direct the level to *aB*, bring the bubble to the middle of the divisions, and instruct your assistant so to place the vane, that the hair in the telescope cuts the middle of the vane, then in a book divide into two columns, the one entitled *Back sights*, the other *Fore sights*, enter the feet, inches, and parts cut by the upper edge of the vane at *aB*, in the column entitled *Back sights*.

Then look toward the other staff *b B*, bring the bubble to the middle of the divisions, and direct your assistant to place the vane so, that the hair cuts the middle of the vane; then enter the feet, inches, and parts cut by the upper edge of the vane, in the column of *Fore sights*.

Now, plant the instrument at A^3, still keeping the staff *Bb* exactly in the same place, and carry the staff *qB* forwards to the place *cB*; now look back to the staff *bB*, and enter the numbers cut by the vane there under the title *Back sights*; then look forwards to *cB*, and enter the observation under the title *Fore sights*. Do the like when the instrument is planted at A^3, A^4, &c. always taking care to keep the staff in the same place when you looked at it for a *Fore sight*, till you have also taken with it a *Back sight*.

Having finished your level, add up the column of *Back sights* into one sum, and the column of *Fore sights* also into one sum; and the difference between these sums is the ascent or descent required. And if the sum of the *Fore sights* be greater than the sum of the *Back sights*, then *e* is lower than *a*; but if the sum of the *Fore sights* be less than the sum of the *Back sights*, *e* is higher than *a*. For example, let the numbers be as in the following table.

Back sights.			*Fore sights.*		
Feet.	Inch.	Tenths.	Feet.	Inch.	Tenths.
3 .	7 ,	5	6 .	4 ,	5
4 .	6 ,	8	8 .	3 ,	2
6 .	0 ,	2	5 .	4 ,	7
9 .	5 ,	0	8 .	7 ,	8
1 .	0 ,	7	9 .	4 ,	8
24 .	8 ,	2	38 .	1 ,	0
			24 .	8 ,	2
			13 .	4 ,	8
Hence the descent is			13 .	4 ,	8

Observations.

1. And if the distances thus taken are short, the curvature of the earth may be rejected. For, if the distance from the instrument be every where about 100 yards, all the curvatures in a mile's work will be less than half an inch.

2. If the distance from the instrument to the hindermost staff, be every where equal to the distance from the instrument to the corresponding staff; the curvature of the earth, and the minute errors of the instrument, will both be destroyed. Hence it will be much best to set the instrument as equally distant from both staves as may be.

3. If the distances of the instrument from the staves, be very unequal and very long, the curvatures must be accounted for, and the distances in order thereto, must be measured.

4. Therefore it appears, that the best method to take a level is to measure the several distances from the instrument to the back and forward station staves; and enter them in the field-book, according to the titles of their several columns, as in the following example; and correct the heights from the table of allowances, which may be done at home when you are about to sum up the heights.

Backwards.			Forwards.		
Distan.	Height	Corrected.	Distan.	Height	Corrected.
Links.	Inches.	Inches.	Links.	Inches.	Inches.
370	3,25	3,24	418	4,36	4,34
420	6,10	6,08	328	7,18	7,17
760	5,38	5,31	289	6,75	6.67
584	7,25	7,21	530	9,53	9,50
326	8,15	8,14	485	11,25	11,22
658	10,25	10,20	376	8,65	8,63
580	6,32	6,29	720	10,34	10,28
3658		46,47	31,46		57,81
3146					46,47
68,04					11,34

So that the fall in 68 chains is about 11 inches and ⅓ of an inch.

Lastly, Though hitherto we have considered the level with one telescope only, the same observations may be applied to a level with a double telescope; and I would advise those who use the double telescope, at every station to turn that end of the telescope forward, which before was the contrary way.

A more general method of levelling, adapted to the surveying of roads and hilly ground, is exhibited in the following example, in which the measures are given in links.

Examples.

Pl. 13. *fig.* 8.

Required the bearing and distance of the place *B* from *A*, and its perpendicular ascent or descent, above or below the horizontal level of *A*.

Sta.	Course or Bearing	Elev. or Depres.	Obl. Dist.	Hor. Dist.	Perpen. Ascent or desc.	Dif. Lat.	Depart.
1	NE79°15	D 17°15′	738	705	218.9	131	692
2	NE75 0	D 21 45	684	635	253.4	164	613
3	NE50 30	E 14 00	976	947	236.1	602	730
4	S E85 15	D 11 30	930	911	185.4	75	908
5	S E70 0	E 19 15	620	585	204.0	200	549
			3948	3783	217.6 Desc.	622 N.	3492 E.

As Dif. Lat. 622
Is to radius S. 20°,
So is Dep. 3492
To T. Bear. 79° 54′.

As S. Bear. 79° 45′
Is to Dep. 3492,
So is radius S. 90°
To Dist. 3547.

As 100 links : 66 feet : : 217.6 links : 143.6 feet, the descent *B* below the level of *A*.

Hence, *B* bears N. 79° 54′ E. from *A*
Nearest horiz. dist. 3547 links.
Sum of obl. dist. 3948 links.
Sum of horiz. dist. 3783 links.
Perp. desc. 217.6L. = 143.6.F.
} answer.

With the angular elevation or depression in the third column, and the oblique distance in the fourth (as course and distance) are found the horizontal distance in the fifth, and the perpendicular ascent or descent on the sixth, for each station (as difference of latitude and departure :) then, with the bearing and horizontal distance we get the difference of latitude and departure in the two last columns.

The ascents and descents in the sixth column are distinguished by the letters *E* and *D* in the third, signifying elevation or depression; and being added separately, the difference of their sums

is set at the bottom of the column with the name of the greater, and shews the perpendicular descent of *B* below the horizontal level of *A*.

In like manner the northings and southings in the seventh column are distinguished by the letters N and S in the second, &c.

PROMISCUOUS QUESTIONS.

The perambulator, or surveying wheel, is so contrived as to turn just twice in the length of a pole or 16½ feet; what then is the diameter?

Answ. 2.626 feet.

2. Two sides of a triangle are respectively 20 and 40 perches; required the third, so that the content may be just an acre?

Answ. either 23.099 or 58.876 perches.

3. I want the length of a line by which my gardener may strike out a round orangery that shall contain just half an acre of ground.

Answ. 27¾ yards.

4. What proportion does the arpent of France, which contains 100 square poles of 18 feet each, bear to the American acre, containing 160 square poles of 16.5 feet each, considering that the length of the French foot is to the American as 16 to 15?

Answ. as 512 to 605.

5. The ellipse in Grosvener square measures 840 links the longest way, and 612 the shortest, within the rails: now the wall being 14 inches thick, it is required to find what quantity of ground it incloses, and how much it stands upon.

Answ. it incloses 4A. 6P. and stands on 1760½ square feet.

6. Requiréd the dimensions of an elliptical acre with the greatest and least diameters in the proportion of 3 to 2?

Answ. 17.479 by 11.653 perches.

7. The paving of a triangular court at 18*d.* per foot, came to 100*l.* The longest of the three sides was 88 feet: what then was the sum of the other two equal sides?

Answ. 106.85 feet.

8. In 110 acres of statute measure, in which the pole is 16½ feet, how many Cheshire acres, where the customary pole is 6 yards, and how many of Ireland, where the pole in use is 7 yards?

Answ. 92A. 1R. 28P. Cheshire; 67A. 3R. 25P. Irish.

9. The three sides of a triangle containing 6A. 1R. 12P. are in the ratio of the three numbers, 9, 8, 6, respectively; required the sides?

Answ. 59.029, 52.47, and 39.353.

10. In a pentangular field, beginning with the south side, and measuring round towards the east, the first or south side is 2735 links, the second 3115, the third 2370, the fourth 2925, and the fifth 2220; also the diagonal from the first angle to the third is 3800 links, and that from the third to the fifth 4010; required the area of the field?

Answ. 117A. 2R. 28 P.

11. Required the dimensions of an oblong garden containing three acres, and bounded by 104 perches of pale fence?

Answ. 40 perches by 12.

12. How many acres are contained in a square meadow, the diagonal of which is 20 perches more than either of its sides?

Answ. 4A. 2R. 11P.

13. If a man six feet high travel round the earth, how much greater will be the circumference described by the top of his head than by his feet?

Answ. 37.69 feet.

N. B. The required difference is equal to the circumference of a circle 6 feet radius, let the magnitude of the earth be what it may.

14. Required the dimensions of a parallelogram containing 200 acres, which is 40 perches longer than wide?

Answ. 200 perches by 160.

15. What difference is there between a lot 28 perches long by 20 broad, and two others, each of half the dimensions?

Answ. 1A. 3R.

PART III.

Containing the Astronomical methods of finding the Latitude, Variation of the compass, &c. with a description of the instruments used in these operations.

SECTION I.

INTRODUCTORY PRINCIPLES.

DAY and night arise from the circumrotation of the Earth. That imaginary line about which the rotation is performed, is called the Axis, and its extremeties are called Poles. That towards the most remote parts of Europe is called the *North Pole*, and its opposite the *South Pole*. The Earth's Axis being produced will point out the *Celestial Poles*.

The Equator is a great circle on the Earth, every point of which is equally distant from the Poles; it divides the Earth into two equal parts, called Hemispheres: that having the North Pole in its centre is called the *Northern Hemisphere*—and the other, the *Southern Hemisphere*. The plane of this circle being produced to the fixed stars, will point out the celestial Equator or Equinoctial. The Equator, as well as all other great circles of the sphere, is divided into 360 equal parts, called *degrees*; each degree is divided into 60 equal parts, called *minutes*; and the sexagesimal division is continued.

NOTE. The ancients having no instruments by which they could make observations with any tolerable degree of accuracy, supposed the length of the year, or annual motion of the earth, to be completed in 360 days: and hence arose the division of the circumference of a circle into the same number of equal parts, which they called *degrees*.

The Meridian of any place, is a semi-circle passing through that place, and terminating at the Poles of the Equator. The other half of this circle is called the *opposite Meridian*.

The Latitude of any place, is that portion of the Meridian of that place, which is contained between the Equator and the given place; and is either *North* or *South*, according as the given place is in Northern or Southern Hemisphere, and therefore cannot exceed 90°.

The Parallel of Latitude of any place, is a circle passing through that place, parallel to the Equator.

The Difference of Latitude between any two places, is an arch of a meridian intercepted between the corresponding parallels of latitude of those places. Hence, if the places lie between the Equator and the same Pole, their difference of latitude is found by subtracting the less latitude from the greater: but if they are on opposite sides of the Equator, the difference of latitude is equal to the sum of the latitudes of both places.

The First Meridian is an imaginary semicircle, passing through any remarkable place, and is therefore arbitrary. Thus, the British esteem that

to be the First Meridian which passes through the Royal Observatory at Greenwich; and the French reckon for their First Meridian, that which passes through the Royal Observatory at Paris.—Formerly many French geographers reckoned the meridian of the island of Ferro to be their First Meridian; and others, that which was exactly 20 degrees to the west of the Paris Observatory. The Germans, again, considered the meridian of the Peak of Teneriffe to be the First Meridian. By this mode of reckoning, Europe, Asia, and Africa, are in east longitude; and North and South America, in west longitude. At present, the first meridian of any country is generally esteemed to be that which passes through the principal Observatory, or chief city of that country.

The Longitude of any place is that portion of the Equator which is contained between the first meridian, and the meridian of that place: and is usually reckoned either *east* or *west*, according as the given place is on the east or west side of the first meridian; and, therefore, cannot exceed 180°.

The Difference of Longitude between any two places is the intercepted arch of the Equator between the meridians of those places, and cannot exceed 180°.

There are three different Horizons, the apparent, the sensible, and the true. The apparent or visible Horizon is the utmost apparent view of the sea or land. The sensible is a plane passing through the eye of an observer, perpendicular to a plumb line hanging freely; And the true or rational Horizon is a plane passing through the centre of the Earth, parallel to the sensible Horizon.

Altitudes observed at sea, are measured from the visible Horizon. At land, when an astronomical quadrant is used, or when observations are taken with a Hadley's quadrant by the method of reflection, the altitude is measured from the sensible Horizon; and in either case, the altitude must be reduced to the true Horizon.

The Zenith of any given place is the point immediately above that place, and is, therefore, the elevated pole of the Horizon: The Nadir is the other pole, or point diametrically opposite.

A Vertical is a great circle passing through the Zenith and Nadir; and, therefore, intersecting the Horizon at right angles.

The Altitude of any celestial body in that portion of a Vertical, which is contained between its centre and the true Horizon. The Meridian Altitude is the distance of the object from the true Horizon, when on the Meridian of the place of observation. When the observed Altitude is corrected for the depression of the Horizon, and the errors arising from the instrument, it is called the *apparent Altitude;* and when reduced to the true Horizon, by applying the parallax in Altitude, it is called the *true Altitude.* Altitudes are expressed in degrees, and parts of a degree.

The Zenith Distance of any object is its distance from the Zenith, or the complement of its Altitude.

The Declination of any object is that portion of its meridian which is contained between the equinoctial and the centre of the object; and is either north or south, according as the star is between the equinoctial and the north or south pole.

The Ecliptic is that great circle, in which the annual revolution of the Earth round the Sun is performed. It is so named, because Eclipses cannot happen but when the moon is in or near that circle. The inclination of the Ecliptic and Equinoctial is at present about 23° 28′; and by comparing ancient with modern observations, the obliquity of the Ecliptic is found to be diminishing—which diminution, in the present century, is about half a second yearly.

The Ecliptic, like all other great circles of the sphere, is divided into 360°; and is further divided into twelve equal parts, called Signs: each Sign, therefore, contains 30°. The names and characters of these Signs are as follows:

Aries,	♈	Cancer,	♋	Libra,	♎	Capricornus,	♑
Taurus,	♉	Leo,	♌	Scorpio,	♏	Aquarius,	♒
Gemini,	♊	Virgo,	♍	Sagittarius,	♐	Pisces,	♓

Since the Ecliptic and Equinoctial are great circles, they, therefore, bisect each other in two points, which are called the *Equinoctial Points*. The Sun is in one of these points in March, and in the other in September; hence, the first is called the *Vernal*, and the other the *Autumnal* Equinox—and that sign which begins at the Vernal Equinox is called *Aries*. Those points of the Ecliptic, which are equidistant from the equinoctial points, are called the *Solstitial Points;* the first the *summer*, and the second the *winter solstice*. That great circle which passes through the equinoctial points and the poles of the earth, is called the *Equinoctial Colure:* and the great circle which passes through the solstitial points and the poles of the earth, is called the *Solstitial Colure.*

When the Sun enters Aries, it is in the Equinoctial; and, therefore, has no declination. From thence it moves forward in the Ecliptic, according to the order of the signs, and advances towards the north pole, by a kind of retarded motion, till it enters Cancer, and is then most distant from the Equinoctial; and moving forward in the Ecliptic, the Sun apparently recedes from the north pole with an accelerated motion till it enters Libra, and being again in the Equinoctial, has no declination; the Sun moving through the signs Libra, Scorpio, and Sagittarius, enters Capricorn; and then its south declination is greatest, and is, therefore, most distant from the north pole; and moving forward through the signs Capricorn, Aquarius, and Pisces, again enters Aries: Hence, a period of the seasons is completed, and this period is called a Solar Year.

The signs Aries, Taurus, Gemini, Cancer, Leo, and Virgo, are called *Northern Signs*, because they are contained in that part of the Ecliptic which is between the Equinoctial and North Pole; and, therefore, while the Sun is in these signs, its declination is *north*: the other six signs are called *Southern Signs*. The signs in the first and fourth quarters of the Ecliptic are called *Ascending Signs*: because, while the Sun is in these signs, it approaches the north pole—and, therefore, in the northern, temperate, and frigid zones, the Sun's meridian altitude daily increases; or, which is the same, the Sun ascends to a greater height above the horizon every day. The signs in the second and third quarters of the Ecliptic are called *Descending Signs*.

The Tropics are circles parallel to the Equinoctial, whose distance therefrom, is equal to the

obliquity of the Ecliptic. The Northern Tropic touches the Ecliptic at the beginning of Cancer, and is, therefore, called the *Tropic of Cancer*; and the Southern Tropic touches the Ecliptic at the beginning of Capricorn, and is hence called the *Tropic of Capricorn*.

Circles about the poles of the Equinoctial, and passing through the poles of the Ecliptic, are called Polar Circles; the distance, therefore, of each Polar Circle from its respective Pole, is equal to the inclination of the Ecliptic and Equinoctial. That Circle which circumscribes the North Pole is called the *Artic*, or *North Polar Circle*; and that towards the South Pole, the *Antartic*, or *South Polar Circle*.

That semicircle which passes through a star, or any given point of the heavens, and the Poles of the Ecliptic, is called a Circle of Latitude.

The Reduced Place of a Star is that point of the Ecliptic, which is intersected by the circle of latitude passing through that star.

The Latitude of a Star is that portion of the circle of latitude contained between the Star and its reduced place—and is either *north* or *south*, according as the Star is between the Ecliptic and the north or south pole thereof.

The Longitude of a Star is that portion of the Ecliptic, contained between the Vernal Equinox and the reduced place of the Star.

SECTION II.

Description of the Instruments requisite in Astronomical Observations.

THE QUADRANT.

IT is generally allowed that we are indebted to John Hadley, Esq. for the invention, or at least for the first public account of that admirable instrument, commonly called Hadley's Quadrant, who in the year 1731, first communicated its principles to the Royal Society, which were by them published soon after in their Philosophical Transactions; before this period, the Cross Staff and Davis's Quadrant were the only instruments used for measuring altitudes at sea, both very imperfect, and liable to considerable error in rough weather; the superior excellence however of Hadley's Quadrant, soon obtained its general use among seamen, and the many improvements this instrument has received from ingenious men at various times, has rendered it so correct, that it is now applied, with the greatest success, to the important purposes of ascertaining both the latitude and longitude at sea, or land.

The Octant or Frame, is generally made of ebony, or other hard wood, and consists of an arch firmly attached to two radii, or bars, which are strengthened and bound by the two braces, in order to prevent it from warping.

The Arch, or Limb, although only the eighth part of a circle, is on account of the double reflection, divided into 90 degrees, numbered 0, 10, 20, 30, &c. from the right towards the left; these are subdivided into 3 parts, containing each 20 minutes, which are again subdivided into single minutes, by means of a scale at the end of the Index. The arch extending from 0 towards the right hand is called the *arch of excess.*

The Index is a flat brass bar, that turns on the centre of the instrument; at the lower end of the Index there is an oblong opening: to one side of this opening a Nonius scale is fixed to subdivide the divisions of the arch; at the bottom or end of the index, there is a piece of brass which bends under the arch, carrying a spring to make the Nonius scale lie close to the divisions; it is also furnished with a screw to fix the Index in any desired position.

Some instruments have an *adjusting* or *tangent-screw*, fitted to the Index, that it may be moved more slowly, and with greater regularity and accuracy than by the hand; it is proper, however, to observe, that the Index must be previously fixed near its right position by the above mentioned screw, before the adjusting screw is put in motion.

The Nonius is a scale fixed to the end of the Index for the purpose, as before observed, of dividing the subdivisions on the Arch into Minutes; it sometimes contains a space of 7 degrees, or 21 subdivisions of the limb, and is divided into 20 equal parts; hence each division on the Nonius will be one-twentieth part greater, that is, one minute longer than the divisions on the Arch; con-

sequently, if the first division of the Nonius marked 0, be set precisely opposite to any degree, the relative position of the Nonius and the Arch must be altered one minute before the next division on the Nonius will coincide with the next division on the Arch, the second division will require a change of 2 minutes, the third of 3 minutes, and so on, till the 20th stroke on the Nonius arrives at the next 20 minutes on the Arch; the 0 on the Nonius will then have moved exactly 20 minutes from the division whence it set out, and the intermediate divisions of each minute, have been regularly pointed out by the divisions of the Nonius.

The divisions of the Nonius scale are in the above case reckoned from the middle towards the right, and from the left towards the middle; therefore the first 10 minutes are contained on the right of the 0, and the other 10 on the left. But this method of reckoning the divisions being found inconvenient, they are more generally counted, beginning from the right-hand towards the left; and then 20 divisions on the Nonius are equal to 19 on the limb, consequently one division on the Arch will exceed one on the Nonius by one-twentieth part, that is, one minute.

The 0 on the Nonius, points out the entire degrees and odd twenty minutes subtended by the objects observed; and if it coincides with a division on the Arch, points out the required angle: thus, suppose the 0 on the Nonius stands at 25 degrees, then 25 degrees will be the measure of the angles observed; if it coincides with the next division on the left hand, 25 degrees 20 minutes is the angle; if with the second division beyond 25

degrees, then the angle will be 25 degrees 40 minutes; and so on in every instance where the 0 on the Nonius coincides with a division on the Arch; but if it does not coincide, then look for a division on the Nonius that stands directly opposite to one on the Arch, and that division on the Nonius gives the odd minutes to be added to that on the Arch nearest the right-hand of the 0 on the Nonius; for example, suppose the Index division does not coincide with 25 degrees, but that the next division to it on the Nonius is the first coincident division, then is the required Angle 25 degrees 1 minute; if it had been the second division, the Angle would have been 25 degrees 2 minutes, and so on to 20 minutes, when the 0 on the Nonius would coincide with the first 20 minutes on the Arch from 25 degrees. Again, let us suppose the 0 on the Nonius to stand between 50 degrees and 50 degrees 20 minutes, and that the 15th division on the Nonius coincides with a division on the Arch, then is the angle 50 degrees 15 minutes. Further, let the 0 on the Nonius stand between 45 degrees 20 minutes and 45 degrees 40 minutes, and at the same time the 14th division on the Nonius stands directly opposite to a division on the Arch, then will the Angle be 45 degrees 34 minutes.

The Index Glass is a plane speculum, or mirror of glass quicksilvered, set in a brass frame, and so placed that the face of it is perpendicular to the plane of the instrument, and immediately over the centre of motion of the Index. This mirror being fixed to the Index moves along with it, and has its direction changed by the motion thereof.

This glass is designed to reflect the image of the Sun, or any other object, upon either of the two horizon glasses, from whence it is reflected to the

eye of the observer. The brass frame, with the glass, is fixed to the Index by the screw; the other screw serves to place it in a perpendicular position, if by any accident it has been put out of order.

The Horizon Glasses are two small speculums on the radius of the Octant; the surface of the upper one is parallel to the Index glass when the 0 on the Nonius is at 0 on the Arch; these mirrors receive the rays of the object reflected from the Index glass, and transmit them to the observer. The fore Horizon glass is only silvered on its lower half, the upper half being transparent, in order that the direct object may be seen through it. The back Horizon glass is silvered at both ends; in the middle there is a transparent slit, through which the Horizon may be seen. Each of these glasses is set in a brass frame, to which there is an axis; this axis passes through the wood work, and is fitted to a lever on the under side of the quadrant, by which the glass may be turned a few degrees on its axis, in order to set it parallel to the Index glass.

To set the glasses perpendicular to the plane of the quadrant, there are two sunk screws, one before and one behind each glass: these screws pass through the plate on which the frame is fixed into another plate, so that by loosening one and tightening the other of these screws, the direction of the frame, with its mirror, may be altered, and thus be set perpendicular to the plane of the instrument.

The Dark Glasses, or Shades, are used to prevent the bright rays of the Sun, or the glare of the Moon, from hurting the eye at the time of observation; there are generally three of them, two red, and one green. They are each set in a brass frame

which turn on a centre, so that they may be used separately or together, as the brightness of the object may require. The green glass may be used also alone, if the Sun be very faint; it is likewise used in taking observations of the Moon; when these glasses are used for the fore observation, they are set immediately before the fore Horizon glass, but in front of the other Horizon glass, when a back observation is made.

The Sight Vanes are pieces of brass, standing perpendicular to the plane of the instrument: that one which is opposite the fore horizon, is called *the fore Sight Vane*, the other *the back Sight Vane*. There are two holes in the fore Sight Vane, the lower of which, and the upper edge of the silvered part of the fore Horizon glass, are equidistant from the plane of the instrument, and the other is opposite to the middle of the transparent part of that glass; the back Sight Vane has only one hole, which is exactly opposite to the middle of the transparent slit in the Horizon glass to which it belongs: but as the back observations are liable to many inconveniences and errors, we shall not give any directions for their practice.

ADJUSTMENTS.

The several parts of the Quadrant being liable to be out of order from a variety of accidental circumstances, it is necessary to examine and adjust them, so that the instrument may be put into a proper state, previous to taking observations.

An instrument properly adjusted, must have the Index glass and Horizon glasses perpendicular to the plane of the Quadrant; the plane of the fore Horizon glass parallel, and that of the back Hori-

zon glass perpendicular to the plane of the Index glass, when the 0 on the Nonius is at 0 on the Arch; hence the Quadrant requires five adjustments, the first three of which being once made, are not so liable as the last two to be out of order; however they should all be occasionally examined in case of an accident.

I. To set the Plane of the Index Glass perpendicular to that of the Instrument.

Place the Index near to the middle of the Arch, and holding the Quadrant in a horizontal position, with the Index glass close to the eye, look obliquely down the glass, in such a manner that you may see the Arch of the Quadrant by direct view, and by reflection at the same time; if they join in one direct line, and the Arch seen by reflection forms an exact plane, or strait line, with the Arch seen by direct view, the glass is perpendicular to the plane of the Quadrant; if not, it must be restored to its right position by loosening the screw, or tightening it, or vice versa, by a contrary operation.

II. To set the Fore Horizon Glass parallel to the Index Glass, the Index being at 0.

Set the 0 on the Nonius exactly against 0 on the Arch, and fix it there by the screw at the under side. Then, holding the Quadrant vertically, with the Arch lowermost, look through the Sight Vane, at the edge of the sea, or any other well defined and distant object. Now, if the Horizon in the silvered part exactly meets, and forms one continued line with that seen through the unsilvered part, the Horizon glass is parallel to the Index glass. But if the Horizons do not coincide,

then loosen the button-screw in the middle of the lever, on the under side of the Quadrant, and move the Horizon glass on its axis, by turning the nut at the end of the adjusting lever, till you have made them perfectly coincide; then fix the lever firmly in this situation by tightening the button-screw. This adjustment ought to be repeated before and after every observation. Some observers adopt the following method, which is called finding the *Index error*. Let the Horizon glass remain fixed, and move the Index till the image and object coincide; then observe whether 0 on the Nonius agrees with 0 on the Arch, if it does not, the number of minutes by which they differ is to be added to the observed altitude or angle, if the 0 on the Nonius be to the right of the 0 on the Arch, but if to the left of the 0 on the limb, it is to be subtracted.

It has already been observed, that that part of the Arch beyond 0, towards the right hand, is called the Arch of excess: the Nonius, when the 0 on it is at that part, must be read the contrary way, or which is the same thing, you may read off the minutes in the usual way, and then their complement to 20 minutes will be the real number, to be added to the degrees and minutes pointed out by the 0 on the Nonius.

III. *To set the Fore Horizon Glass perpendicular to the Plane of the Quadrant.*

Having previously made the above adjustment, incline the Quadrant on one side as much as possible, provided the Horizon continues to be seen in both parts of the glass; if when the instrument is thus inclined, the edge of the sea seen through the lower hole of the Sight Vane continues to form

one unbroken line, the Horizon glass is perfectly adjusted; but if the reflected Horizon be separated from that seen by direct vision, the speculum is not perpendicular to the plane of the Quadrant: then if the limb of the Quadrant is inclined towards the Horizon, with the face of the instrument upwards, and the reflected sea appears higher than the real sea, you must slacken the screw before the Horizon glass, and tighten that which is behind it; but if the reflected sea appears lower, the contrary must be performed. Care must be always taken in this adjustment to loosen one screw before the other is screwed up, and to leave the adjusting screws tight, or so as to draw with a moderate force against each other.

This adjustment may be also made by the Sun, Moon, or a Star; in this case the Quadrant is to be held in a vertical position; if the image seen by reflection appears to the right or left of the object seen directly, then the glass must be adjusted as before by the two screws.

It will be necessary, after having made this adjustment, to examine if the Horizon glass still continues to be parallel to the Index glass, as sometimes by turning the sunk screws the plane of the Horizon glass will have its position altered.

USE OF HADLEY'S QUADRANT.

The use of the Quadrant is to ascertain the Angle subtended by two distant objects at the eye of the observer; but principally to observe the altitude of a celestial object above the Horizon: this is pointed out by the Index when one of the

objects seen by reflection is made to coincide with the other, seen through the transparent part of the Horizon glass.

To take an Altitude of the Sun, Moon, or a Star, by a Fore Observation.

Having previously adjusted the instrument, place the 0 on the Nonius opposite to 0 on the Arch, and turn down one or more of the screens, according to the brightness of the Sun; then apply the eye to the upper hole in the fore Sight Vane, if the Sun's image be very bright, otherwise to the lower, and holding the Quadrant vertically, look directly towards the Sun so as to let it be behind the silvered part of the Horizon glass, then the coloured Sun's image will appear on the speculum; move the Index forward till the Sun's image, which will appear to descend, just touches the Horizon with its lower or upper limb; if the upper hole be looked through, the Sun's image must be made to appear in the middle of the transparent part of the Horizon, but if it be the lower hole, hold the Quadrant so that the Sun's image may be bisected by the line joining the silvered and transparent parts of the Horizon glass.

The Sun's limb ought to touch that part of the Horizon immediately under the Sun, but as this point cannot be exactly ascertained, it will be therefore necessary for the observer to give the Quadrant a slow motion from side to side, turning at the same time upon his heel, by which motion the Sun will appear to sweep the Horizon, and must be made just to touch it at the lowest part of the Arch; the degrees and minutes then pointed out by the Index on the Limb of the Quadrant will be the observed altitude of that limb which is brought in contact with the Horizon.

When the meridian or greatest altitude is required, the observation should be commenced a short time before the object comes to the meridian; being brought down to the Horizon, it will appear for a few minutes to rise slowly; when it is again to be made to coincide with the Horizon by moving the Index forward; this must be repeated until the object begins to descend, when the Index is to be secured, and the observation to be read off.

From this description of the Quadrant and its use, the manner of adjusting and using the Sextant will be readily apprehended. Our limits will not allow a particular description of this excellent instrument.

The Artificial Horizon.

In many cases it happens that altitudes are to be taken on land by the Quadrant or Sextant; which, for want of a natural horizon, can only be obtained by an artificial one. There have been a variety of these sorts of instruments made, but the kind now described is allowed to be the only one that can be depended upon. It consists of a wood or metal framed roof, containing two true parallel glasses of about 5 by 2½ inches, fixed not too tight in the frames of the roof. This serves to shelter from the air a wooden trough filled with quicksilver. In making an observation by it with the Quadrant, or Sextant, the reflected image of the sun, moon, or other object, is brought to coincide with the same object reflected from the glasses of the Quadrant or Sextant: half the angle shown upon the limb is the altitude above the horizon or level required. It is necessary in a set of observations that the roof be always placed the same way. When done with, the roof folds up flatways, and, with the quicksilver in a bottle, &c. is packed into a portable flat case.

SECTION III.

To find the Latitude by the Meridian Altitude of the Sun.

The Latitude of a place is its distance from the equator, either North or South; and is measured by an arch of a Meridian contained between the Zenith and the equinoctial. Hence, if the distance of any heavenly body from the Zenith, when on the Meridian, and its declination, or the number of degrees and minutes it is to the Northward, or Southward of the equinoctial, be given, the Latitude may thence be found.

The Altitude of the Sun, observed by a Quadrant, or Sextant, requires four corrections in order to obtain the true altitude; these are the Semidiameter, Dip, Refraction, and Parallax.

By the Semidiameter of the Sun is meant the angle subtended by the distance from its centre to its apparent circumference. The quantity of this angle is given for every sixth day in the year in table 10.

The Dip of the Horizon is a vertical angle contained between a Horizontal plane passing through the eye of an observer, and a line drawn from his eye to the visible Horizon. This Dip is found in Table 8, when the visible horizon is formed by the apparent junction of the water and sky; but in Table 9, when land intervenes. In this case, the line that separates the land and water is used as the Horizon, and its distance from the observer must be duly estimated.

The Refraction of any celestial body is the difference between its apparent place, and that wherein it would be seen, if the space between the observer and object, was either a void, or of a uniform density. Table 6 contains this Refraction.

That part of the heavens, in which an object appears, when viewed from the surface of the earth, is called its apparent place; and the point, wherein it would be seen, at the same instant, if viewed from the centre of the earth, is called its true place; the difference between the true and apparent places, is called the Parallax. The Sun's Parallax in Altitude is found in Table 7.

RULE

For finding the Latitude from the Sun's Meridian Altitude.

Having observed with the Quadrant, or Sextant, the altitude of the Sun's lower limb above the visible horizon,—or the line of separation of the land from the water, when that horizon is obstructed by land—add thereto the semidiameter, taken from table 10 at the given day of the month, or the one nearest to it, and from this sum subtract the

Dip, from table 8 or 9, corresponding to the height of the observer's eye above the surface of the water; and this result will be the apparent altitude of the Sun's centre. Then take the refraction from table 6, and the parallax from table 7, corresponding to this altitude, and the difference of these quantities, called the correction, being subtracted from the apparent altitude, the remainder will be the Sun's true altitude; the complement of which will be its zenith distance, north or south, according as the Sun bears south or north, at the time of observation.

When the observation has been made by bringing the Sun's image in the Quadrant, or Sextant, to a just coincidence with its image in an artificial horizon, half the angle shown on the instrument is the Sun's apparent altitude, which must be corrected by the corresponding refraction and parallax only, in order to obtain the true altitude.

Take the Sun's declination from table 13, answering to the given year, month, and day, observing whether it be north or south, and reduce it, as there directed, by the help of table 14, to the longitude of the place of observation. Then the sum, or difference of the zenith distance, and declination, according as they are of the same, or of a contrary denomination, will be the latitude of the place of observation, of the same name with the greater of those two quantities.

Examples.

1st. March 10th, 1811, in longitude 70° W. the Mer. Alt. of ⊙ L. L. was observed to be 49° 50 bearing south—height of the observer's eye 12 feet, required the latitude in

Mer. Alt. ⊙ L. L.	=	49° 50 00″ S.
Semidiameter	=	+ 16 08
Dip—table 8	=	−03 19
Ap. Alt.	=	50 02 49
Correction	=	−42
True Alt.		50 02 07
		90
Zenith Dist.	=	39 57 53N.
Reduced Dec.	=	4 15 29S.
Latitude.		35 42 24N.

2d. May 10th, 1811, in long. 80° W. at noon, the angular distance between the ⊙ bearing south, and its reflected image in the artificial horizon was found with a sextant to be 98° 30′ 40″ required the latitude.

98° 30′ 40″ ÷ 2 = 49° 15′ 20″

⊙ Ap. Alt.	=	49° 15′ 20″ S.
Correction	=	−43
True Alt.	=	49 14 37
		90
Zenith Dist.	=	40 45 23 N.
Reduced Dec.	=	17 30 34 N.
Latitude.	=	58 15 57 N.

3d. July 24th, 1811, in long. 62° 30′ W. the Mer. Alt of ⊙ L. L. above the border of a lake was observed, by a person on the opposite shore, to be 56° 32′ bearing S.—the distance of that border of the lake beneath the sun being 5 miles from the observer, and the height of his eye above the surface of the water, 8 feet; required the latitude.

Mer. Alt. ⊙ L. L.	=	56° 32′ 00″ S.
Semidiameter	=	+ 15 48
Dip from table 9	=	−2 36
Ap. Alt.	=	56 45 12
Correction	=	−33
True Alt.	=	56 44 39
		90
Zenith Dist.	=	33 15 21 N.
Reduced Dec.	=	19 59 46 N
Latitude	=	53 15 07 N.

4th. October 11th, 1812, in long. 91° W. the Meridian Altitude of ⊙ L. L. above the visible horizon was observed to be 47° 13′ bearing S. the height of the eye being 25 feet; required the latitude.

Mer. Alt. ⊙ L. L.	=	47° 13′ 00″ S.
Semidiameter	=	+ 16 06
Dip from table 8	=	−4 47
Ap. Alt	=	47 24 19
Correction	=	−46
True Alt.	=	47 23 33
		90
Zenith Dist.	=	42 36 27 N.
Reduced Dec.	=	6 58 16 S
Latitude	=	35 38 11 N

N. B. For the various other methods of finding the latitude by observation, the surveyor must apply to books professedly on practical astronomy. He will, however, find a method of observing the latitude by the altitude of the north star, in the explanation of table 12, annexed to this treatise.

SECTION IV.

VARIATION OF THE COMPASS.

The variation of the compass is the deviation of the points of the mariner's compass from the cor-

responding points of the horizon, and is termed east or west variation, according as the magnetic needle, or north point of the compass, is inclined to the eastward or westward of the true north point of the horizon.

The true amplitude of any celestial object is an arch of the horizon contained between the true east or west points thereof, and the centre of the object at the time of its rising or setting; or it is the degrees and minutes, the object rises or sets to the northward or southward of the true east or west points of the horizon.

The magnetic amplitude, is an arch contained between the east or west points of the compass and the centre of the object at rising or setting; or it is the bearing of the object, by compass, when in the horizon.

The true azimuth of an object is an arch of the horizon contained between the true meridian and the azimuth circle passing through the centre of the object.

The magnetic azimuth, is an arch contained between the magnetic meridian and the azimuth circle passing through the centre of the object; or it is the bearing of the object, by compass, at any time when it is above the horizon.

The true amplitude, or azimuth, is found by calculation, and the magnetic amplitude, or azimuth, by an azimuth compass.

THE AZIMUTH COMPASS.

From the accounts of the compasses, heretofore given in the description of surveying instruments, it is presumed that the nature and properties of the azimuth compass will be readily conceived by a contemplative inspection; the directions for its uses are as follow:

To observe the Sun's amplitude.

Turn the compass-box until the vane containing the magnifying glass is directed towards the sun: and when the bright speck, or rays of the sun collected by the magnifying glass, falls upon the slit in the other vane, stop the card by means of the nonius, and read off the amplitude.

Without using the magnifying-glass, the sight may be directed through the dark glass towards the sun; and in this case, the card is to be stopped when the sun is bisected by the thread in the other vane.

The observation should be made when the sun's lower limb appears somewhat more than his semidiameter above the horizon, because his centre is really then in the horizon, although it is ap-

parently elevated on account of the refraction of the atmosphere: this is particularly to be noticed in high latitudes.

To observe the Sun's Azimuth.

Raise the magnifying-glass to the upper part of the vane, and move the box, as before directed, until the bright speck fall on the other vane, or on the line in the horizontal bar; the card is then to be stopped, and the divisions being read off, will be the sun's magnetic azimuth.

If the card vibrate considerably at the time of observation, it will be better to observe the extreme vibrations, and take their mean as the magnetic azimuth. When the magnetic azimuth is observed, the altitude of the object must be taken, in order to obtain the true azimuth.

It will conduce much to accuracy if several azimuths be observed, with the corresponding altitudes, and the mean of the whole taken for the observation.

To find the variation of the Compass by an amplitude.

Rule—1. To the log. secant of the latitude, rejecting the index, add the log. sine of the sun's declination, corrected for the time and place of observation; their sum will be the log. sine of the true amplitude, to be reckoned from the east in the morning, or the west in the afternoon, towards the north or south, according to the declination.

2. Then if the true and magnetic amplitudes, be both north or both south, their difference is the variation; but if one be north and the other south, their sum is the variation; and to know whether it be easterly or westerly, suppose the observer looking towards that point of the compass representing the magnetic amplitude: then if the true amplitude be to the right hand of the magnetic amplitude, the variation is east, but if to the left hand, it is west.

EXAMPLE I.

July 3, 1812, in latitude 9° 36′ S. the Sun was observed to rise E. 12° 42′ N: required the variation of the compass.

Latitude	9° 36′ S.	-	Secant	0.00613
Declination	22 59 N.	-	Sine	9.59158
True amplitude E.	23 20 N.	-	Sine	9.59771
Mag. amplitude E.	12 42 N.			

Variation - 10 38 west, because the true amplitude is to the left of the magnetic.

EXAMPLE II.

September 24, 1812, in latitude 26° 32′ N. and longitude 78° W. the Sun's centre was observed to set W. 6° 15′ S. about 6h. P. M. required the variation of the compass.

Sun's declination	0° 30′ S.		
Corr. for long. 78° W.	+ 5		
Corr. for time 6h. P. M.	+ 6		
Reduced declination	0 41	Sine	8.07650
Latitude	26 32	Secant	0.04834
True amplitude	W. 0 46 S.	Sine	81.2484
Mag. amplitude	W. 6 15 S.		

Variation 5 29 east, because the true amplitude is to the right hand of the magnetic.

To find the Variation of the Compass by an Azimuth.

RULE. 1.—Reduce the Sun's declination to the time and place of observation, and compute the true altitude of the Sun's centre.

2. Subtract the Sun's declination from 90°, when the latitude and declination are of the same name, or add it to 90°, when they are of contrary names; and the sum, or remainder, will be the Sun's polar distance.

3. Add together the Sun's polar distance, the latitude of the place, and the altitude of the Sun; take the difference between half their sum and the polar distance, and note the remainder.

4. Then add together

the log. secant of the altitude } rejecting their
the log. secant of the latitude } indices.
the log. co. sine of the half sum,
and the log. co. sine of the remainder.

5. Half the sum of these four logarithms will be the sine of an arch, which doubled, will be the Sun's true azimuth; to be reckoned from the south in north latitude, and from the north in south latitude: towards the east in the morning, and towards the west in the afternoon.

6. Then if the true and observed azimuths be both on the east, or both on the west side of the meridian, their difference is the variation: but if one be on the east, and the other on the west side of the meridian, their sum is the variation; and to know if it be east or west, suppose the observer looking towards that point of the compass representing the magnetic azimuth; then if the true azimuth be to the right of the magnetic, the variation is east, but if the true be to the left of the magnetic, the variation is west.

EXAMPLE.

November 2, 1812, in latitude 25° 32′ N. and longitude 75° W. the altitude of the Sun's lower limb was observed to be 15° 36′, about 4h. 10m. P. M. his magnetic azimuth at that time being S. 58° 32′ W. and the height of the eye 18 feet; required the variation of the compass.

Sun's de. Nov. 2, at n.	14° 48′ S.	Obs. alt. Sun's lower limb	15° 36′
Corr. for long. 75° W.	+ 4	Semidiameter 16′, Dip - 4	+ 12
Co. for ti. 4h. 10m. af. n.	+ 3		
Reduced declination	14 55		15 48
	90 00	Refraction - -	3
Polar distance	104 55	True altitude -	15 45
Altitude -	15 45	- Secant	0.01662
Latitude -	25 32	- Secant	0.04463
Sum -	146 12		
Half -	73 6	- Co. sine	9.46345
Remainder	31 49	- Co. sine	9.92929
	32 14		19.45399
	2	- Sine	9.72699
True azimuth S.	64 28 W.		
Mag. azimuth S.	58 32 W.		

Variation - 5 56 east, because the true azimuth is to the right of the magnetic.

To draw a true meridian line to a map, having the variation and magnetical meridian given.

On any magnetical meridian or parallel, upon which the map is protracted, set off an angle from the north towards the east, equal to the degrees or quantity of variation, if it be westerly, or from the north towards the west, if it be easterly, and the line which constitutes such an angle with the magnetical meridian, will be a true meridian line.

For if the variation be westerly, the magnetical meridian will be the quantity of variation of the west side of the true meridian, but if easterly, on the east side; therefore the true meridian must be a like quantity on the east side of the magnetical one, when the variation is westerly, and on the west side when it is easterly.

To lay out a true meridian line by the circumferentor.

If the variation be westerly, turn the box about till the north of the needle points as many degrees from the flower-de-luce towards the east of the box, or till the south of the needle points the like number of degrees from the south towards the west, as are the number of degrees contained in the variation, and the index will be then due north and south: therefore if a line be struck out in the direction thereof, it will be a true meridian line.

If the variation was easterly, let the north of the needle point as many degrees from the flower-de-luce towards the west of the box, or let the south of the needle point as many degrees towards the east, as are the number of degrees contained in the variation, and then the north and south of the box will coincide with the north and south points of the horizon, and consequently a line being laid out by the direction of the index, will be a true meridian line.

This will be found to be very useful in setting an horizontal dial, for if you lay the edge of the index by the base of the stile of the dial, and keep the angular point of the stile toward the south of the box, and allow the variation as before, the dial will then be due north and south, and in its proper situation, provided the plane upon which it is fixed be duly horizontal, and the sun be south at noon; but in places where it is north at noon, the angular point of the index must be turned to the north.

How maps may be traced by the help of a true meridian line.

If all maps had a true meridian line laid out upon them, it would be easy by producing it, and drawing parallels, to make out field-notes; and by knowing the variation, and allowing it upon every bearing, and having the distances, you would have notes sufficient for a trace. But a true meridian line is seldom to be met with, therefore we are obliged to have recourse to the foregoing method. It is therefore advised to lay out a true meridian line upon every map.

To find the difference between the present variation, and that at a time when a tract was formerly surveyed, in order to trace or run out the original lines.

If the old variation be specified in the map or writings, and the present be known, by calculation or otherwise, then the difference is im-

mediately seen by inspection; but as it more frequently happens, that neither is certainly known, and as the variation of different instruments is not always alike at the same time, the following practical method will be found to answer every purpose.

Go to any part of the premises where any two adjacent corners are known; and, if one can be seen from the other, take their bearing; which, compared with that of the same line in the former survey, shows the difference. But if trees, hills, &c. obstruct the view of the object, run the line according to the given bearing, and observe the nearest distance between the line so run and the corner, then,

As the length of the whole line
Is to 57.3 degrees,*
So is the said distance
To the difference of variation required.

EXAMPLE.

Suppose it be required to run a line which some years ago bore NE. 45°, distance 80 perches, and in running this line by the given bearing, the corner is found 20 links to the left hand; what allowance must be made on each bearing to trace the old lines, and what is the present bearing of this particular line by the compass?

	P.		Deg.		L.
As	80	:	57.3	: :	20
	25		20		
	2|000		1146.0(0°. 34'		
			60		
			2)68|760.0		

Answer, 34 minutes; or a little better than half a degree to the left hand, is the allowance required, and the line in question bears N. 44° 26'. E.

Note. The different variations do not affect the area in the calculation, as they are similar in every part of the survey.

* 57.3 Is the radius of a circle (nearly) in such parts as the circumference contains 360.

FINIS.

TABLE I.

LOGARITHMS OF NUMBERS.

EXPLANATION.

LOGARITHMS are a series of numbers so contrived, that the sum of the Logarithms of any two numbers, is the logarithm of the product of these numbers. Hence it is inferred, that if a rank, or series of numbers in arithmetical progression, be adapted to a series of numbers in geometrical progression, any term in the arithmetical progression will be the logarithm of the corresponding term in the geometrical progression.

This table contains the common logarithms of all the natural numbers from 0 to 10000, calculated to six decimal places; such, on account of their superior accuracy, being preferable to those, that are computed only to five places of decimals.

In this form, the logarithm of 1 is 0, of 10, 1; of 100, 2; of 1000, 3 &c. Whence the logarithm of any term between 1 and 10, being greater than 0, but less than 1, is a proper fraction, and is expressed decimally. The logarithm of each term between 10 and 100, is 1, with a decimal fraction annexed; the logarithm of each term between 100 and 1000 is 2, with a decimal annexed, and so on. The integral part of the logarithm is called the Index, and the other the decimal part.—Except in the first hundred logarithms of this Table, the Indexes are not printed, being so readily supplied by the operator from this general rule; *the Index of a Logarithm is always one less than the number of figures contained in its corresponding natural number—exclusive of fractions, when there are any in that number.*

The Index of the logarithm of a number, consisting in whole, or in parts, of integers, is affirmative; but when the value of a number is less than unity, or 1, the index is negative, and is usually marked by the sign, —, placed either before, or above the index. If the first significant figure of the decimal fraction be adjacent to the decimal point, the index is 1,— or its arithmetical complement 9; if there is one cipher between the decimal point and the first significant figure in the decimal, the index is — 2, or its arith. comp. 8; if two ciphers, the index is — 3, or 7, and so on; but the arithmetical complements, 9, 8, 7 &c. are rather more conveniently used in trigonometrical calculations.

The decimal parts of the logarithms of numbers, consisting of the same figures, are the same, whether the number be integral, fractional, or mixed : thus,

	of the natural number	the Log.	or
	23450	4.370143	
	2345.0	3.370143	
	234.50	2.370143	
	23.450	1.370143	
	2.3450	0.370143	
	2.3450	1.370143	9.370143
	.02345	2.370143	8.370143
	.002345	3.370143	7.370143

N. B. The arithmetical complement of the logarithm of any number, is found by subtracting the given logarithm from that of the radius, or by subtracting each of its figures from 9, except the last, or right-hand figure, which is to be taken from 10. The arithmetical complement of an index is found by subtracting it from 10.

PROBLEM I.

To find the logarithm of any given number.

Rules.

1. If the number is under 100, its logarithm is found in the first page of the table, immediately opposite thereto.

Thus the Log. of 53, is 1.724276.

2. If the number consists of three figures, find it in the first column of the following part of the table, opposite to which, and under 0, is its logarithm.

Thus the Log, of 384 is 2.584331—prefixing the index 2, because the natural number contains 3 figures.

Again the log. of 65.7 is 1.817565—prefixing the index 1, because there are two figures only in the integral part of the given number.

3. If the given number contains four figures, the three first are to be found, as before, in the side column, and under the fourth at the top of the table is the logarithm required.

Thus the log. of 8735 is 3.941263—for against 873, the three first figures found in the left side column, and under 5, the fourth figure found at the top, stands the decimal part of the logarithm, viz .941263, to which prefixing the index, 3, because there are four figures in the natural number, the proper logarithm is obtained.

Again the logarithm of 37.68 is 1.576111—Here the decimal part of the logarithm is found, as before, for the four figures ; but the index is 1, because there are two integral places only in the natural number.

4. If the given number exceeds four figures, find the difference between the logarithms answering to the first four figures of the given number, and the next following logarithm ; multiply this difference by the remaining figures in the given number, point off as many figures to the right-hand as there are in the multiplier, and the remainder, add-

ed to the logarithm, answering to the first four figures, will be the required logarithm, nearly.

Thus; to find the logarithm of 738582;

the log. of the first four figures, viz. 7385	.868350
the next greater logarithm	= 868409
Dif.	= 59
to be multiplied by the remaining figures	= 82
	118
	472
	48|38

then to .868350
add 48

the sum 5.868398, with the proper index prefixed, is the required logarithm.

5. The logarithm of a vulgar-fraction is found by subtracting the logarithm of the denominator from that of the numerator; and that of a mixed quantity is found by reducing it to an improper fraction, and proceeding as before.

Thus to find the Logarithm of $\frac{7}{8}$;

from the log. of 7 = 0.845098
subtract the log. of 8 = 0.903090

Remainder = 9.942008 = the required log.

PROBLEM II.

To find the number answering to any given logarithm.

Rules.

1. Find the next less logarithm to that given in the column marked o at the top, and continue the sight along that horizontal line, and a logarithm the same as that given, or very near it, will be found; then the three first figures of the corresponding natural number will be found opposite thereto in the side column, and the fourth figure immediately above it, at the top of the page. If the index of the given logarithm is 3, the four figures thus found are integers; if the index is 2, the three first figures are integers, and the fourth is a decimal, and so on.

Thus the log.	3.132580	gives the Nat. Numb.	1357
	2.132580	gives	135.7
	1.132580	gives	13.57
	0.132580	gives	1.357
	9.132580	gives	.1357 &c.

2. If the given logarithm cannot be exactly found in the table, and if more than four figures be wanted in the corresponding natural number; then find the difference between the given and the next less loga-

rithms, to which annex as many ciphers as there are figures required above four in the natural number; which divide by the difference between the next less, and next greater logarithms, and the quotient annexed to the four figures formerly found, will give the required natural number.

Thus to find the natural number of the log. 4.828991;
the next less log. is .828982 which gives 6735;
the next greater log. is 829046

Dif. = 64
next less log. = 828982
given log. = 828991

Dif. with one o annexed = 90
then 64) 90 (1.4
.64

260
256

4

therefore 1.4 being annexed to 6735, the required natural number, 67351.4, is now obtained.

TABLE I.

LOGARITHMS OF NUMBERS.

No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Lo
1	0.000000	21	1.322219	41	1.612784	61	1.785330	81	1.908485
2	0.301030	22	1.342423	42	1.623249	62	1.792392	82	1.913814
3	0.477121	23	1.361728	43	1.633468	63	1.799341	83	1.919078
4	0.602060	24	1.380211	44	1.643453	64	1.806180	84	1.924279
5	0.698970	25	1.397940	45	1.653213	65	1.812913	85	1.929419
6	0.778151	26	1.414973	46	1.662758	66	1.819544	86	1.934498
7	0.845098	27	1.431364	47	1.672098	67	1.826075	87	1.939519
8	0.903090	28	1.447158	48	1.681241	68	1.832509	88	1.944483
9	0.954243	29	1.462398	49	1.690196	69	1.838849	89	1.949390
10	1.000000	30	1.477121	50	1.698970	70	1.845098	90	1.954243
11	1.041393	31	1.491362	51	1.707570	71	1.851258	91	1.959041
12	1.079181	32	1.505150	52	1.716003	72	1.857332	92	1.963788
13	1.113943	33	1.518514	53	1.724276	73	1.863323	93	1.968483
14	1.146128	34	1.531479	54	1.732394	74	1.869232	94	1.973128
15	1.176091	35	1.544068	55	1.740363	75	1.875061	95	1.977724
16	1.204120	36	1.556302	56	1.748188	76	1.880814	96	1.982271
17	1.230449	37	1.568202	57	1.755875	77	1.886491	97	1.986772
18	1.255273	38	1.579784	58	1.763428	78	1.892095	98	1.991226
19	1.278754	39	1.591065	59	1.770852	79	1.897627	99	1.995635
20	1.301030	40	1.602060	60	1.778151	80	1.903090	100	2.000000

LOGARITHMS OF NUMBERS.

No.	0	1	2	3	4	5	6	7	8	9
100	000000	000434	000868	001301	001734	002166	002598	003029	003460	003891
101	004321	004751	005180	005609	006038	006466	006894	007321	007748	008174
102	008600	009206	009451	009876	010300	010724	011147	011570	011993	012415
103	012837	013259	013680	014100	014520	014940	015360	015779	016197	016616
104	017033	017451	017868	018284	018700	019116	019532	019947	020361	020775
105	021189	021603	022016	022428	022841	023252	023664	024075	024486	024896
106	025306	025715	026124	026533	026942	027350	027757	028164	028571	028978
107	029384	029789	030195	030600	031004	031408	031812	032216	032619	033021
108	033424	033826	034227	034628	035029	035430	035830	036229	036629	037028
109	037426	037825	038223	038620	039017	039414	039811	040207	040602	040998
110	041393	041787	042182	042575	042069	043362	043755	044148	044540	044932
111	045323	045714	046105	046495	046885	047275	047664	048053	048442	048830
112	049218	049606	049993	050380	050766	051152	051538	051924	052309	052694
113	053078	053463	053846	054230	054613	054996	055378	055760	056142	056524
114	056905	057286	057666	058046	058426	058805	059185	059563	059942	060320
115	060698	061075	061452	061829	062206	062582	062958	063333	063709	064083
116	064458	064832	065206	065580	065953	066326	066699	067071	067443	067814
117	068186	068557	068928	069298	069668	070038	070407	070776	071145	071514
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914	960946	960994	961041	961089	961136	961184	961231	961279	961326	961374
915	961421	961469	961516	961563	961611	961658	961706	961753	961801	961848
916	961895	961943	961990	962038	962085	962132	962180	962227	962275	962322
917	962369	962417	962464	962511	962559	962606	962653	962701	962748	962795
918	962843	962890	962937	962985	963032	963079	963126	963174	963221	963268
919	963315	963363	963410	963457	963504	963552	963599	963646	963693	963741
920	963788	963835	963882	963929	963977	964024	964071	964118	964165	964212
921	964260	964307	964354	964401	964448	964495	964542	964590	964637	964684
922	964731	964778	964825	964872	964919	964966	965013	965060	965108	965155
923	965202	965249	965296	965343	965390	965437	965484	965531	965578	965625
924	965672	965719	965766	965813	965860	965907	965954	966001	966048	966095
925	966142	966189	966236	966283	966329	966376	966423	966470	966517	966564
926	966611	966658	966705	966752	966798	966845	966892	966939	966986	967033
927	967080	967127	967173	967220	967267	967314	967361	967408	967454	967501
928	967548	967595	967642	967688	967735	967782	967829	967875	967922	967969
929	968016	968062	968109	968156	968203	968249	968296	968343	968389	958436
930	968483	968530	968576	968623	968670	968716	968763	968810	968856	968903
931	968950	968996	969043	969090	969136	969183	969229	969276	969323	969369
932	969416	969462	969509	969556	969602	969649	969695	969742	969788	969835
933	969882	969928	969975	970021	970068	970114	970161	970207	970254	970300
934	970347	970393	970440	970486	970533	970579	970626	970672	970719	970765
935	970812	970858	970904	970951	970997	971044	971090	971137	971183	971229
936	971276	971322	971369	971415	971461	971508	971554	971600	971647	971693
937	971740	971786	971832	971879	971925	971971	972018	972064	972110	972156
938	972203	972249	972295	972342	972388	972434	972480	972527	972573	972619
939	972666	972712	972758	972804	972851	972897	972943	972989	973035	973082
	0	1	2	3	4	5	6	7	8	9

No.	0	1	2	3	4	5	6	7	8	9
940	973128	973174	973220	973266	973313	973359	973405	973451	973497	9735
941	973590	973636	973682	973728	973774	973820	973866	973913	973959	9740
942	974051	974097	974143	974189	974235	974281	974327	974373	974420	97446
943	974512	974558	974604	974650	974696	974742	974788	974834	974880	97492
944	974972	975018	975064	975110	975156	975202	975248	975294	975340	97538
945	975432	975478	975524	975570	975616	975661	975707	975753	975799	97584
946	975891	975937	975983	976029	976075	976121	976166	976212	976258	97630
947	976350	976396	976442	976487	976533	976579	976625	976671	976717	97676
948	976808	976854	976900	976946	976991	977037	977083	977129	977175	97722
949	977266	977312	977358	977403	977449	977495	977541	977586	977632	97767
950	977724	977769	977815	977861	977906	977952	977998	978043	978089	97813
951	978180	978226	978272	978317	978363	978409	978454	978500	978546	97859
952	978637	978683	978728	978774	978819	978865	978911	978956	979002	97904
953	979093	979138	979184	979230	979275	979321	979366	979412	979457	97950
954	979548	979594	979639	979685	979730	979776	979821	979867	979912	97995
955	980003	980049	980094	980140	980185	980231	980276	980322	980367	98041
956	980458	980503	980549	980594	980640	980685	980730	980776	980821	98086
957	980912	980957	981003	981048	981093	981139	981184	981229	981275	98132
958	981365	981411	981456	981501	981547	981592	981637	981683	981728	98177
959	981819	981864	981909	981954	982000	982045	982090	982135	982181	98222
960	982271	982316	982362	982407	982452	982497	982543	982588	982633	98267
961	982723	982769	982814	982859	982904	982949	982994	983040	983085	98313
962	983175	983220	983265	983310	983356	983401	983446	983491	983536	98358
963	983626	983671	983716	983762	983807	983852	983897	983942	983987	98403
964	984077	984122	984167	984212	984257	984302	984347	984392	984437	98448
965	984527	984572	984617	984662	984707	984752	984797	984842	984887	98493
966	984977	985022	985067	985112	985157	985202	985247	985292	985337	98538
967	985426	985471	985516	985561	985606	985651	985696	985741	985786	98583
968	985875	985920	985965	986010	986055	986100	986144	986189	986234	98627
969	986324	986369	986413	986458	986503	986548	986593	986637	986682	98672
970	986772	986816	986861	986906	986951	986995	987040	987085	987130	98717
971	987219	987264	987309	987353	987398	987443	987487	987532	987577	98762
972	987666	987711	987756	987800	987845	987890	987934	987979	988024	98806
973	988113	988157	988202	988247	988291	988336	988381	988425	988470	98851
974	988559	988603	988648	988693	908737	988782	988826	988871	988915	98896
975	989005	989049	989094	989138	989183	989227	989272	989316	989361	98940
976	989450	989494	989539	989583	989628	989672	989717	989761	989806	98985
977	989895	989939	989983	990028	990072	990117	990161	990206	990250	99029
978	990339	990383	990428	990472	990516	990561	990605	990650	990694	99073
979	990783	990827	990871	990916	990960	991004	991049	991093	991137	99118
980	991226	991270	991315	991359	991403	991448	991492	991536	991580	99162
981	991669	991713	991757	991802	991846	991890	991934	991979	992023	99206
982	992111	992156	992200	992244	992288	992333	992377	992421	992465	99250
983	992553	992598	992642	992686	992730	992774	992818	992863	992907	99295
984	992995	993039	993083	993127	993172	993216	993260	993304	993348	99339
985	993436	993480	993524	993568	993613	993657	993701	993745	993789	99383
986	993877	993921	993965	994009	994053	994097	994141	994185	994229	99427
987	994317	994361	994405	994449	994493	994537	994581	994625	994669	99471
988	994757	994801	994845	994889	994933	994977	995021	995064	995108	99515
989	995196	995240	995284	995328	995372	995416	995460	995504	995547	99559
990	995635	995679	995723	995767	995811	995854	995898	995942	995986	99603
991	996074	996117	996161	996205	996249	996293	996336	996380	996424	99646
992	996512	996555	996599	996643	996687	996730	996774	996818	996862	99690
993	996949	996993	997037	997080	997124	997168	997212	997255	997299	99734
994	997386	997430	997474	997517	997561	997605	997648	997692	997736	99777
995	997823	997867	997910	997954	997998	998041	998085	998128	998172	99821
996	998259	998303	998346	998390	998434	998477	998521	998564	998608	99865
997	998695	998739	998782	998826	998869	998913	998956	999000	999043	99908
998	999130	999174	999218	999261	999305	999348	999392	999435	999478	99952
999	999565	999609	999652	999696	999739	999783	999826	999870	999913	99995
	0	1	2	3	4	5	6	7	8	9

TABLE 2.

Logarithmic Sines, Tangents, and Secants.

This table contains the logarithmic, or, as they are sometimes called, the artificial sines, tangents, and secants, to each degree and minute of the quadrant, with their complements or co-sines, co-tangents, and co-secants, to six places of figures besides the index.

To find the Logarithmic Sine, Co-Sine, &c. of any Number of Degrees and Minutes.

If the given degrees be under 45, they are to be taken from the top, and the minutes f om the left side column, opposite to which in that column with the name of the logarithm at the top, will be found the required logarithm. But if the degrees be more than 45, they will be found at the bottom of the page, and the minutes in the right side column; likewise the name of the logarithm is to be taken from the bottom of the page.

When the given degrees exceed 90, they are to be subtracted from 180 degrees, and the logarithm of the remainder taken out as before. Or the logarithmic sine, tangent, &c. of degrees more than 90, is the logarithmic co-sine, co-tangent, &c. of their excess above 90 degrees.

EXAMPLES.

	°	′		logarithm.
Required the log. sine of	36	32	-	9.774729
- - co-sine of	61	18	-	9.681443
- - tangent of	54	17	-	10 143263
- - co-tang. of	42	50	-	10.032877
- - secant of	19	27	-	10.025519
- - co-secant of	70	33	-	10.025519
- - sine of	108	36		
- or sine of	71	24	-	9.976702
- or co-sine of	18	36		

To find the Degrees and Minutes nearest corresponding to a given Logarithmic Sine, Co-sine, &c.

Look in the column marked at the top or bottom with the name of the given logarithm, and when the nearest to it is found, the corresponding degrees and minutes will be those required. observing that when the name is at the top of the column, the degrees are to be taken from the top and the minutes from the left side column, but if the name is at the bottom, the corresponding degrees will be there likewise, and the minutes in the right side column.

EXAMPLES.

The degrees and minutes corresponding to the

log. sine	9.265390	are	10°	37′
co-sine	9.528461		70	16
tangent	9.70156		26	42
secant	10.25413		56	9

The logarithmic sines, &c. taken out to degrees and minutes only are in general sufficiently accurate, but in some of the more rigid astronomical calculations, it is frequently necessary to take them out to the nearest second; when this is the case they are to be found in the following manner:

To find the sine, tangent, &c. of an arch expressed in degrees, minutes and seconds.

RULE.

Find the sine, tangent, &c. answering to the given degree and minute, and also that answering to the next greater minute; multiply the difference between them by the given number of seconds, and divide the product by 60; then, the quotient added to the sine, tangent, &c. of the given degree and minute, or subtracted from the co-sine, co-tangent, &c. will give the quantity required, nearly.

If the arch be less than three degrees, it will be necessary to use the following rule:—

To the arithmetical complement of the given degrees and minutes reduced to seconds, add the logarithm of the given degrees, minutes, and seconds, reduced to seconds, and the log.-sine, tangent, &c. of the given degrees and minutes, the sum, rejecting 10 from the index, will be the log.-sine, tangent, &c. of the proposed number of degrees, minutes, and seconds.

To find the degrees, minutes, and seconds, answering to a given logarithmic sine, tangent, &c.

RULE.

Find the degrees minutes and seconds answering to the next less logarithmic sine, tangent, &c. which subtract from that given; multiply the remainder by 60, and divide the product by the difference between the next less and next greater logarithms, and the quotient will be the seconds to be annexed to the degrees and minutes before found.

If the given logarithm is that of the sine or tangent of a small arch—then, to the arithmetical complement of the next less logarithm in the tables, add the given logarithm, and the logarithm of the degrees and minutes, in seconds, answering to the next less logarithm, the sum, rejecting radius, will be the logarithm of the number of seconds in the required arch.

Sine 0 Degree.

M	0″	10″	20″	30″	40″	50″	
0		5.685575	5.986605	6.162696	6.287635	6.384545	59
1	6.463726	6.530673	6.588665	6.639817	6.685575	6.726967	58
2	6.764756	6.799518	6.831703	6.861666	6.889695	6.916024	57
3	6.940847	6.964328	6.986605	7.007794	7.027997	7.047303	56
4	7.065786	7.083515	7.100548	7.116938	7.132733	7.147973	55
5	7.162696	7.176936	7.190725	7.204089	7.217054	7.229643	54
6	7.241877	7.253776	7.265358	7.276639	7.287635	7.298358	53
7	7.308824	7.319043	7.329027	7.338787	7.348332	7.357672	52
8	7.366816	7.375770	7.384544	7.393145	7.401578	7.409850	51
9	7.417968	7.425937	7.433762	7.441449	7.449002	7.456426	50
10	7.463725	7.470904	7.477966	7.484915	7.491754	7.498487	49
11	7.505118	7.511649	7.518083	7.524423	7.530672	7.536832	48
12	7.542906	7.548897	7.554806	7.560635	7.566387	7.572065	47
13	7.577668	7.583201	7.588664	7.594059	7.599388	7.604652	46
14	7.609853	7.614993	7.620072	7.625093	7.630056	7.634963	45
16	7.639816	7.644615	7.649361	7.654056	7.658701	7.663297	44
15	7.667844	7.672345	7.676799	7.681208	7.685573	7.689894	43
17	7.694173	7.698410	7.702606	7.706762	7.710879	7.714957	42
18	7.718997	7.722999	7.726965	7.730896	7.734791	7.738651	41
19	7.742477	7.746270	7.750031	7.753758	7.757454	7.761119	40
20	7.764754	7.768358	7.771932	7.775477	7.778994	7.782482	39
21	7.785943	7.789376	7.792782	7.796162	7.799515	7.802843	38
22	7.806146	7.809423	7.812677	7.815905	7.819111	7.822292	37
23	7.825451	7.828586	7.831700	7.834791	7.837860	7.840907	36
24	7.843934	7.846939	7.849924	7.852888	7.855833	7.858757	35
25	7.861662	7.864548	7.867414	7.870262	7.873092	7.875902	34
26	7.878695	7.881470	7.884228	7.886968	7.889690	7.892396	33
27	7.895085	7.897758	7.900414	7.903054	7.905678	6.908287	32
28	7.910879	7.913457	7.916019	7.918566	7.921098	7.923616	31
29	7 926119	7 928608	7.931082	7.933543	7.935989	7.938422	30
30	7.940842	7.943248	7.945641	7.948020	7.950387	7.952741	29
31	7.955082	7.957410	7.959727	7.962031	7.964322	7.966602	28
32	7.968870	7.971126	7.973370	7.975603	7.977824	7.980034	27
33	7.982233	7.984421	7.986598	7.988764	7.990919	7.993064	26
34	7.995198	7.997322	7.999435	8.001538	8.003631	8.005714	25
35	8.007787	8.009850	8.011903	8.013947	8.015981	8.018005	24
36	8.020021	8.022027	8.024023	8.026011	8.027989	8.029959	23
37	8.031919	8.033871	8.035814	8.037749	8.039675	8 041592	22
38	8 043501	8.045401	8.047294	8.049178	8.051054	8 052922	21
39	8.054781	8.056633	8.058477	8.060314	8.062142	8.063963	20
40	8.065776	8.067582	8.069380	8.071171	8.072955	8.074731	19
41	8.076500	8.078261	8.080016	8.081764	8.083504	8.085238	18
42	8.086965	8.088684	8.090398	8.092104	8.093804	8.095497	17
43	8.097183	8.098863	8.100537	8.102204	8.103864	8.105519	16
44	8.107167	8.108809	8.110444	8.112074	8.113697	8.115315	15
45	8.116926	8.118532	8.120131	8.121725	8.123313	8.124895	14
46	8.126471	8.128042	8.129606	8.131166	8.132720	8.134268	13
47	8.135810	8.137348	8.138879	8.140406	8.141927	8.143443	12
48	8.144953	8.146458	8.147959	8.149453	8.150943	8.152428	11
49	8.153907	8.155382	8.156852	8.158316	8.159776	8.161231	10
50	8.162681	8.164126	8 165566	8.167002	8.168433	8.169859	9
51	8.171280	8.172697	8.174109	8.175517	8.176920	8.178319	8
52	8.179713	8.181102	8.182488	8.183868	8.185245	8.186617	7
53	8.187985	8.189348	8.190707	8.192062	8.193413	8.194760	6
54	8.196102	8.197440	8.198774	8.200104	8.201430	8.202752	5
55	8.204070	8.205384	8.206694	8.208000	8 209302	8.210601	4
56	8.211895	8.213185	8.214472	8.215755	8.217034	8.218309	3
57	8.219581	8.220849	8.222113	8.223374	8.224631	8.225884	2
58	8.227133	8.228380	8.229622	8.230861	8.232096	8.233328	1
59	8.234557	8.235782	8.237003	8.238221	8.239436	8.240647	0
	60″	50″	40″	30″	20″	10″	M

Co-sine 89 Degrees.

Tangent 0 Degree,

M	0″	10″	20″	30″	40″	50″	
0		5.685575	5.986605	6.162696	6.287635	6.384545	59
1	6.463726	6.530673	6.588665	6.639817	6.685575	6.726968	58
2	6.764756	6.799518	6.831703	6.861666	6.889695	6.916024	57
3	6.940847	6.964329	6.986605	7.007794	7.027998	7.047303	56
4	7.065786	7.083515	7.100548	7.116939	7.132733	7.147973	55
5	7.162696	7.176937	7.190725	7.204089	7.217054	7.229643	54
6	7.241878	7.253777	7.265359	7.276640	7.287635	7.298359	53
7	7.308825	7.319044	7.329028	7.338788	7.348333	7.357673	52
8	7.366817	7.375772	7.384546	7.393146	7.401579	7.409852	51
9	7.417970	7.425939	7.433764	7.441451	7.449004	7.456428	50
10	7.463727	7.470906	7.477968	7.484917	7.491756	7.498490	49
11	7.505120	7.511651	7.518085	7.524426	7.530675	7.536835	48
12	7.542909	7.548900	7.554808	7.560638	7.566390	7.572068	47
13	7.577671	7.583204	7.588667	7.594062	7.599391	7.604655	46
14	7.609857	7.614996	7.620076	7.625097	7.630060	7.634968	45
15	7.639820	7.644619	7.649366	7.654061	7.658706	7.663301	44
16	7.667849	7.672350	7.676804	7.681213	7.685578	7.689900	43
17	7.694179	7.698416	7.702612	7.706768	7.710885	7.714962	42
18	7.719003	7.723005	7.726972	7.730902	7.734797	7.738658	41
19	7.742484	7.746277	7.750037	7.753765	7.757462	7.761127	40
20	7.764761	7.768365	7.771940	7.775485	7.779002	7.782490	39
21	7.785951	7.789384	7.792790	7.796170	7.799524	7.802852	38
22	7.806155	7.809432	7.812686	7.815915	7.819120	7.822302	37
23	7.825460	7.828596	7.831710	7.834801	7.837870	7.840918	36
24	7.843944	7.846950	7.849935	7.852900	7.855844	7.858769	35
25	7.861674	7.864560	7.867426	7.870274	7.873104	7.875915	34
26	7.878708	7.881483	7.884240	7.886981	7.889704	7.892410	33
27	7.895099	7.897771	7.900428	7.903068	7.905692	7.908301	32
28	7.910894	7.913471	7.916034	7.918581	7.921113	7.923631	31
29	7.926134	7.928623	7.931098	7.933559	7.936006	7.938439	30
30	7.940858	7.943265	7.945657	7.948037	7.950404	7.952758	29
31	7.955100	7.957428	7.959745	7.962049	7.964341	7.966621	28
32	7.968889	7.971145	7.973389	7.975622	7.977844	7.980054	27
33	7.982253	7.984441	7.986618	7.988785	7.990940	7.993085	26
34	7.995219	7.997343	7.999456	8.001560	8.003653	8.005736	25
35	8.007809	8.009872	8.011926	8.013970	8.016004	8.018029	24
36	8.020044	8.022051	8.024047	8.026035	8.028014	8.029984	23
37	8.031945	8.033897	8.035840	8.037775	8.039701	8.041618	22
38	8.043527	8.045428	8.047321	8.049205	8.051081	8.052949	21
39	8.054809	8.056661	8.058506	8.060342	8.062171	8.063992	20
40	8.065806	8.067612	8.069410	8.071201	8.072985	8.074761	19
41	8.076531	8.078293	8.080047	8.081795	8.083536	8.085270	18
42	8.086997	8.088717	8.090430	8.092137	8.093837	8.095530	17
43	8.097217	8.098897	8.100571	8.102239	8.103899	8.105554	16
44	8.107202	8.108845	8.110481	8.112110	8.113734	8.115352	15
45	8.116963	8.118569	8.120169	8.121763	8.123351	8.124933	14
46	8.126510	8.128081	8.129646	8.131206	8.132760	8.134308	13
47	8.135851	8.137389	8.138921	8.140447	8.141969	8.143485	12
48	8.144996	8.146501	8.148001	8.149497	8.150987	8.152472	11
49	8.153952	8.155426	8.156896	8.158361	8.159821	8.161276	10
50	8.162727	8.164172	8.165613	8.167049	8.168480	8.169906	9
51	8.171328	8.172745	8.174158	8.175566	8.176969	8.178368	8
52	8.179763	8.181152	8.182538	8.183919	8.185296	8.186668	7
53	8.188036	8.189400	8.190760	8.192115	8.193466	8.194813	6
54	8.196156	8.197494	8.198829	8.200159	8.201485	8.202808	5
55	8.204126	8.205440	8.206750	8.208057	8.209359	8.210658	4
56	8.211953	8.213243	8.214530	8.215814	8.217093	8.218369	3
57	8.219641	8.220909	8.222174	8.223434	8.224692	8.225945	2
58	8.227195	8.228442	8.229685	8.230924	8.232160	8.233392	1
59	8.234621	8.235846	8.237068	8.238286	8.239501	8.240713	0
	60″	50″	40″	30″	20″	10″	M

Co-Tangent 89 Degrees.

Sine 1 Degree

M	0″	10″	20″	30″	40″	50″	
0	8.241855	8.243060	8.244261	8.245459	8.246654	8.247845	59
1	8.249033	8.250218	8.251400	8.252578	8.253753	8.254925	58
2	8.256094	8.257260	8.258423	8.259582	8.260739	8.261892	57
3	8.263042	8.264190	8.265334	8.266475	8.267613	8.268749	56
4	8.269881	8.271010	8.272137	8.273260	8.274381	8.275499	55
5	8.276614	8.277726	8.278835	8.279941	8.281045	8.282145	54
6	8.283243	8.284339	8.285431	8.286521	8.287608	8.288692	53
7	8.289773	8.290852	8.291928	8.293002	8.294073	8.295141	52
8	8.296207	8.297270	8.298330	8.299388	8.300443	8.301496	51
9	8.302546	8.303594	8.304639	8.305681	8.306721	8.307759	50
10	8.308794	8.309827	8.310857	8.311885	8.312910	8.313933	49
11	8.314954	8.315972	8.316987	8.318001	8.319012	8.320020	48
12	8.321027	8.322031	8.323033	8.324032	8.325029	8.326024	47
13	8.327016	8.328007	8.328995	8.329980	8.330964	8.331945	46
14	8.332924	8.333901	8.334876	8.335848	8.336819	8.337787	45
15	8.338753	8.339717	8.340678	8.341638	8.342596	8.343551	44
16	8.344504	8.345455	8.346405	8.347352	8.348297	8.349240	43
17	8.350180	8.351119	8.352056	8.352991	8.353924	8.354855	42
18	8.355783	8.356710	8.357635	8.358558	8.359479	8.360398	41
19	8.361315	8.362230	8.363143	8.364054	8.364964	8.365871	40
20	8.366777	8.367681	8.368582	8.369482	8.370380	8.371277	39
21	8.372171	8.373063	8.373954	8.374843	8.375730	8.376615	38
22	8.377499	8.378380	8.379260	8.380138	8.381015	8.381889	37
23	8.382762	8.383633	8.384502	8.385370	8.386236	8.387100	36
24	8.387962	8.388823	8.389682	8.390539	8.391395	8.392249	35
25	8.393101	8.393951	8.394800	8.395647	8.396493	8.397337	34
26	8.398179	8.399020	8.399859	8.400696	8.401532	8.402366	33
27	8.403199	8.404030	8.404859	8.405687	8.406513	8.407338	32
28	8.408161	8.408983	8.409803	8.410621	8.411438	8.412254	31
29	8.413068	8.413880	8.414691	8.415500	8.416308	8.417114	30
30	8.417919	8.418722	8.419524	8.420324	8.421123	8.421921	29
31	8.422717	8.423511	8.424304	8.425096	8.425886	8.426675	28
32	8.427462	8.428248	8.429032	8.429815	8.430597	8.431377	27
33	8.432156	8.432933	8.433709	8.434484	8.435257	8.436029	26
34	8.436800	8.437569	8.438337	8.439103	8.439868	8.440632	25
35	8.441394	8.442155	8.442915	8.443674	8.444431	8.445186	24
36	8.445941	8.446694	8.447446	8.448196	8.448946	8.449694	23
37	8.450440	8.451186	8.451930	8.452672	8.453414	8.454154	22
38	8.454893	8.455631	8.456368	8.457103	8.457837	8.458570	21
39	8.459301	8.460032	8.460761	8.461489	8.462215	8.462941	20
40	8.463665	8.464388	8.465110	8.465830	8.466550	8.467268	19
41	8.467985	8.468701	8.469416	8.470129	8.470841	8.471553	18
42	8.472263	8.472971	8.473679	8.474386	8.475091	8.475795	17
43	8.476498	8.477200	8.477901	8.478601	8.479299	8.479997	16
44	8.480693	8.481388	8.482082	8.482775	8.483467	8.484158	15
45	8.484848	8.485536	8.486224	8.486910	8.487596	8.488280	14
46	8.488963	8.489645	8.490326	8.491006	8.491685	8.492363	13
47	8.493040	8.493715	8.494390	8.495064	8.495736	8.496408	12
48	8.497078	8.497748	8.498416	8.499084	8.499750	8.500415	11
49	8.501080	8.501743	8.502405	8.503067	8.503727	8.504386	10
50	8.505045	8.505702	8.506358	8.507014	8.507668	8.508321	9
51	8.508974	8.509625	8.510275	8.510925	8.511573	8.512221	8
52	8.512867	8.513513	8.514157	8.514801	8.515444	8.516086	7
53	8.516726	8.517366	8.518005	8.518643	8.519280	8.519916	6
54	8.520551	8.521186	8.521819	8.522451	8.523083	8.523713	5
55	8.524343	8.524972	8.525599	8.526226	8.526852	8.527477	4
56	8.528102	8.528725	8.529347	8.529969	8.530589	8.531209	3
57	8.531828	8.532446	8.533063	8.533679	8.534295	8.534909	2
58	8.535523	8.536136	8.536747	8.537358	8.537969	8.538578	1
59	8.539186	8.539794	8.540401	8.541007	8.541612	8.542216	0
	60″	50″	40″	30″	20″	10″	M

Co-sine 88 Degrees.

Tangent 1 Degree.

M	0″	10″	20″	30″	40″	50″	
0	8.241921	8.243126	8.244328	8.245526	8.246721	8.247913	59
1	8.249101	8.250287	8.251469	8.252648	8.253823	8.254996	58
2	8.256165	8.257331	8.258494	8.259654	8.260811	8.261965	57
3	8.263115	8.264263	8.265408	8.266549	8.267688	8.268824	56
4	8.269956	8.271086	8.272213	8.273337	8.274458	8.275576	55
5	8.276691	8.277804	8.278913	8.280020	8.281124	8.282225	54
6	8.283323	8.284419	8.285512	8.286602	8.287689	8.288774	53
7	8.289856	8.290935	8.292012	8.293086	8.294157	8.295226	52
8	8.296292	8.297355	8.298416	8.299474	8.300530	8.301583	51
9	8.302633	8.303682	8.304727	8.305770	8.306811	8.307849	50
10	8.308884	8.309917	8.310948	8.311976	8.313002	8.314025	49
11	8.315046	8.316065	8.317081	8.318095	8.319106	8.320115	48
12	8.321122	8.322127	8.323129	8.324128	8.325126	8.326121	47
13	8.327114	8.328105	8.329093	8.330080	8.331064	8.332045	46
14	8.333025	8.334002	8.334977	8.335950	8.336921	8.337890	45
15	8.338856	8.339821	8.340783	8.341743	8.342701	8.343657	44
16	8.344610	8.345562	8.346512	8.347459	8.348405	8.349348	43
17	8.350289	8.351229	8.352166	8.353101	8.354035	8.354966	42
18	8.355895	8.356823	8.357748	8.358671	8.359593	8.360512	41
19	8.361430	8.362345	8.363259	8.364171	8.365080	8.365988	40
20	8.366894	8.367799	8.368701	8.369601	8.370500	8.371397	39
21	8.372291	8.373184	8.374076	8.374965	8.375853	8.376738	38
22	8.377622	8.378504	8.379385	8.380263	8.381140	8.382015	37
23	8.382889	8.383760	8.384630	8.385498	8.386364	8.387229	36
24	8.388092	8.388953	8.389812	8.390670	8.391526	8.392381	35
25	8.393234	8.394085	8.394934	8.395782	8.396628	8.397472	34
26	8.398315	8.399156	8.399996	8.400834	8.401670	8.402505	33
27	8.403338	8.404170	8.405000	8.405828	8.406655	8.407480	32
28	8.408304	8.409126	8.409946	8.410765	8.411583	8.412399	31
29	8.413213	8.414026	8.414837	8.415647	8.416456	8.417262	30
30	8.418068	8.418872	8.419674	8.420475	8.421274	8.422072	29
31	8.422869	8.423664	8.424458	8.425250	8.426040	8.426830	28
32	8.427618	8.428404	8.429189	8.429973	8.430755	8.431536	27
33	8.432315	8.433093	8.433870	8.434645	8.435419	8.436191	26
34	8.436962	8.437732	8.438500	8.439267	8.440033	8.440797	25
35	8.441560	8.442322	8.443082	8.443841	8.444599	8.445355	24
36	8.446110	8.446864	8.447616	8.448367	8.449117	8.449866	23
37	8.450613	8.451359	8.452104	8.452847	8.453589	8.454330	22
38	8.455070	8.455808	8.456545	8.457281	8.458016	8.458749	21
39	8.459481	8.460212	8.460942	8.461670	8.462398	8.463124	20
40	8.463849	8.464572	8.465295	8.466016	8.466736	8.467455	19
41	8.468172	8.468889	8.469604	8.470318	8.471031	8.471743	18
42	8.472454	8.473163	8.473871	8.474579	8.475285	8.475990	17
43	8.476693	8.477396	8.478097	8.478798	8.479497	8.480195	16
44	8.480892	8.481588	8.482283	8.482976	8.483669	8.484360	15
45	8.485050	8.485740	8.486428	8.487115	8.487801	8.488486	14
46	8.489170	8.489852	8.490534	8.491215	8.491894	8.492573	13
47	8.493250	8.493927	8.494602	8.495276	8.495949	8.496622	12
48	8.497293	8.497963	8.498632	8.499300	8.499967	8.500633	11
49	8.501298	8.501962	8.502625	8.503287	8.503948	8.504608	10
50	8.505267	8.505925	8.506582	8.507238	8.507893	8.508547	9
51	8.509200	8.509852	8.510503	8.511153	8.511802	8.512451	8
52	8.513098	8.513744	8.514389	8.515034	8.515677	8.516319	7
53	8.516961	8.517602	8.518241	8.518880	8.519517	8.520154	6
54	8.520790	8.531425	8.522059	8.522692	8.523324	8.523956	5
55	8.524586	8.525215	8.525844	8.526472	8.527098	8.527724	4
56	8.528349	8.528973	8.529596	8.530218	8.530840	8.531460	3
57	8.532080	8.532698	8.533316	8.533933	8.534549	8.535164	2
58	8.535779	8.536392	8.537005	8.537616	8.538227	8.538837	1
59	8.539447	8.540055	8.540662	8.541269	8.541875	8.542480	0
	60″	50″	40″	30″	20″	10″	M

Co-tangent 88 Degrees.

M	0°'
0	8.241855
1	8.249033
2	8.25609
3	8.26304
4	8.2698
5	8.2766
6	8.283
7	8.289
8	8.296
9	8.302
10	8.30
11	8 31
12	8.3
13	8.3
14	8.3
15	8.3
16	8.
17	8.
18	8.
19	8
20	8
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M	Sine	Co-sine	Tang.	Co-tang.	Secant.	Co-sec.	M
				Infinite.	10.000000	Infinite.	60
				13.536274	10.000000	13.536274	59
				13.235244	10.000000	13.235244	58
				13.059153	10.000000	13.059153	57
				12.934214	10.000000	12.934214	56
			[illegible]	12.837304	10.000000	12.837304	55
			[illegible]	12.758122	10.000001	12.758123	54
			…3825	12.691175	10.000001	12.691176	53
			…06817	12.633183	10.000001	12.633184	52
			…417970	12.582030	10.000001	12.582032	51
			7.463727	12.536273	10.000002	12.536274	50
			7.505120	12.494880	10.000002	12.494882	49
			7.542909	12.457091	10.000003	12.457094	48
		[illegible]	7.577672	12.422328	10.000003	12.422332	47
		…9996	7.609857	12.390143	10.000004	12.390147	46
		…99996	7.639820	12.360180	10.000004	12.360184	45
		…999995	7.667849	12.332151	10.000005	12.332155	44
		…999995	7.694179	12.305821	10.000005	12.305827	43
		9.999994	7.719003	12.280997	10.000006	12.281003	42
		9.999993	7.742484	12.257516	10.000007	12.257522	41
		9.999993	7.764761	12.235239	10.000007	12.235246	40
	[illegible]	9.999992	7.785951	12.214049	10.000008	12.214057	39
	[illegible]	9.999991	7.806155	12.193845	10.000009	12.193854	38
	[illegible]	9.999990	7.825460	12.174540	10.000010	12.174549	37
	…934	9.999989	7.843944	12.156056	10.000011	12.156066	36
	…662	9.999989	7.861674	12.138326	10.000011	12.138338	35
	…8695	9.999988	7.878708	12.121292	10.000012	12.121305	34
	…895085	9.999987	7.895099	12.104901	10.000013	12.104915	33
	…910879	9.999986	7.910894	12.089106	10.000014	12.089121	32
	…926119	9.999985	7.926134	12.073866	10.000015	12.073881	31
	…940842	9.999983	7.940858	12.059142	10.000017	12.059158	30
	7.955082	9.999982	7.955100	12.044900	10.000018	12.044918	29
32	7.968870	9.999981	7.968889	12.031111	10.000019	12.031130	28
33	7.982233	9.999980	7.982253	12.017747	10.000020	12.017767	27
34	7.995198	9.999979	7.995219	12.004781	10.000021	12.004802	26
35	8.007787	9.999977	8.007809	11.992191	10.000023	11.992213	25
36	8.020021	9.999976	8.020045	11.979955	10.000024	11.979979	24
37	8.031919	9.999975	8.031945	11.968055	10.000025	11.968081	23
38	8.043501	9.999973	8.043527	11.956473	10.000027	11.956499	22
39	8.054781	9.999972	8.054809	11.945191	10.000028	11.945219	21
40	8.065776	9.999971	8.065806	11.934194	10.000029	11.934224	20
41	8.076500	9.999969	8.076531	11.923469	10.000031	11.923500	19
42	8.086965	9.999968	8.086997	11.913003	10.000032	11.913035	18
43	8.097183	9.999966	8.097217	11.902783	10.000034	11.902817	17
44	8.107167	9.999964	8.107202	11.892798	10.000036	11.892833	16
45	8.116926	9.999963	8.116963	11.883037	10.000037	11.883074	15
46	8.126471	9.999961	8.126510	11.873490	10.000039	11.873529	14
47	8.135810	9.999959	8.135851	11.864149	10.000041	11.864190	13
48	8.144953	9.999958	8.144996	11.855004	10.000042	11.855047	12
49	8.153907	9.999956	8.153952	11.846048	10.000044	11.846093	11
50	8.162681	9.999954	8.162727	11.837273	10.000046	11.837319	10
51	8.171280	9.999952	8.171328	11.828672	10.000048	11.828720	9
52	8.179713	9.999950	8.179763	11.820237	10.000050	11.820287	8
53	8.187985	9.999948	8.188036	11.811964	10.000052	11.812015	7
54	8.196102	9.999946	8.196156	11.803844	10.000054	11.803898	6
55	8.204070	9.999944	8.204126	11.795874	10.000056	11.795930	5
56	8.211895	9.999942	8.211953	11.788047	10.000058	11.788105	4
57	8.219581	9.999940	8.219641	11.780359	10.000060	11.780419	3
58	8.227134	9.999938	8.227195	11.772805	10.000062	11.772866	2
59	8.234557	9.999936	8.234621	11.765379	10.000064	11.765443	1
60	8.241855	9.999934	8.241922	11.758078	10.000066	11.758145	0
M	Co-sine	Sine	Co tang	Tang.	Co-sec.	Secant	M

89 Degrees.

1 Degree.

M	Sine.	Co-sine.	Tang.	Co-tang	Secant.	Co-sec.	M
0	8.241855	9.999934	8.241921	11.758079	10.000066	11.758145	60
1	8.249033	9.999932	8.249102	11.750898	10.000068	11.750967	59
2	8.256094	9.999929	8.256165	11.743835	10.000071	11.743906	58
3	8.263042	9.999927	8.263115	11.736885	10.000073	11.736958	57
4	8.269881	9.999925	8.269956	11.730044	10.000075	11.730119	56
5	8.276614	9.999922	8.276691	11.723309	10.000078	11.723386	55
6	8.283243	9.999920	8.283323	11.716677	10.000080	11.716757	54
7	8.289773	9.999918	8.289856	11.710144	10.000082	11.710227	53
8	8.296207	9.999915	8.296292	11.703708	10.000085	11.703793	52
9	8.302546	9.999913	8.302634	11.697366	10.000087	11.697454	51
10	8.308794	9.999910	8.308884	11.691116	10.000090	11.691206	50
11	8.314954	9.999907	8.315046	11.684954	10.000093	11.685046	49
12	8.321027	9.999905	8.321122	11.678878	10.000095	11.678973	48
13	8.327016	9.999902	8.327114	11.672886	10.000098	11.672984	47
14	8.332924	9.999899	8.333025	11.666975	10.000101	11.667076	46
15	8.338753	9.999897	8.338856	11.661144	10.000103	11.661247	45
16	8.344504	9.999894	8.344610	11.653390	10.000106	11.655496	44
17	8.350181	9.999891	8.350289	11.649711	10.000109	11.649819	43
18	8.355783	9.999888	8.455895	11.644105	10.000112	11.644217	42
19	8.361315	9.999885	8.361430	11.638570	10.000115	11.638685	41
20	8.366777	9.999882	8.366895	11.633105	10.000118	11.633223	40
21	8.372171	9.999879	8.372292	11.627708	10.000121	11.627829	39
22	8.377499	9.999876	8.377622	11.622378	10.000124	11.622501	38
23	8.382762	9.999873	8.382889	11.617111	10.000127	11.617238	37
24	8.387962	9.999870	8.388092	11.611908	10.000130	11.612038	36
25	8.393101	9.999867	8.393234	11.606766	10.000133	11.606899	35
26	8.398179	9.999864	8.398315	11.601685	10.000136	11.601821	34
27	8.403199	9.999861	8.403338	11.596662	10.000139	11.596801	33
28	8.408161	9.999858	8.408304	11.591696	10.000142	11.591839	32
29	8.413068	9.999854	8.413213	11.586787	10.000146	11.586932	31
30	8.41791[illegible]	9.999851	8.418068	11.581932	10.000149	11.582081	30
31	8.422717	9.999848	8.422869	11.577131	10.000152	11.577283	29
32	8.427462	9.999844	8.427618	11.572382	10.000156	11.572538	28
33	8.432156	9.999841	8.432315	11.567685	10.000159	11.567844	27
34	8.436800	9.999838	8.436962	11.563038	10.000162	11.563200	26
35	8.441394	9.999834	8.441560	11.558440	10.000166	11.558606	25
36	8.445941	9.999831	8.446110	11.553890	10.000169	11.554059	24
37	8.450440	9.999827	8.450613	11.549387	10.000173	11.549560	23
38	8.454893	9.999824	8.455070	11.544930	10.000176	11.545107	22
39	8.459301	9.999820	8.459481	11.540519	10.000180	11.540699	21
40	8.463665	9.999816	8.463849	11.536151	10.000184	11.536335	20
41	8.467985	9.999813	8.468172	11.531828	10.000187	11.532015	19
42	8.472263	9.999809	8.472454	11.527546	10.000191	11.527737	18
43	8.476498	9.999805	8.476693	11.523307	10.000195	11.523502	17
44	8.480693	9.999801	8.480892	11.519108	10.000199	11.519307	16
45	8.484848	9.999797	8.485050	11.514950	10.000203	11.515152	15
46	8.488963	9.999794	8.489170	11.510830	10.000206	11.511037	14
47	8.493040	9.999790	8.493250	11.506750	10.000210	11.506960	13
48	8.497078	9.999786	8.497293	11.502707	10.000214	11.502922	12
49	8.501080	9.999782	8.501298	11.498702	10.000218	11.498920	11
50	8.505045	9.999778	8.505267	11.494733	10.000222	11.494955	10
51	8.508974	9.999774	8.509200	11.490800	10.000226	11.491026	9
52	8.512867	9.999769	8.513098	11.486902	10.000231	11.487133	8
53	8.516726	9.999765	8.516961	11.483039	10.000235	11.483274	7
54	8.520551	9.999761	8.520790	11.479210	10.000239	11.479449	6
55	8.524343	9.999757	8.524586	11.475414	10.000243	11.475657	5
56	8.528102	9.999753	8.528349	11.471651	10.000247	11.471898	4
57	8.531828	9.999748	8.532080	11.467920	10.000252	11.468172	3
58	8.535523	9.999744	8.535779	11.464221	10.000256	11.464477	2
59	8.539186	9.999740	8.539447	11.460553	10.000260	11.460814	1
60	8.542819	9.999735	8.543084	11.456916	10.000265	11.457181	0
M	Co-sine.	Sine.	Co-tang.	Tang.	Co-sec.	Secant.	M

88 Degrees.

No.	0	1	2	3	4	5	6	7	8	9
760	880814	880871	880928	880985	881042	881099	881156	881213	881270	881328
761	881385	881442	881499	881556	881613	881670	881727	881784	881841	881898
762	881955	882012	882069	882126	882183	882240	882297	882354	882411	882468
763	882524	882581	882638	882695	882752	882809	882866	882923	882980	883037
764	883093	883150	883207	883264	883321	883377	883434	883491	883548	883605
765	883661	883718	883775	883832	883888	883945	884002	884059	884115	884172
766	884229	884285	884342	884399	884455	884512	884569	884625	884682	884739
767	884795	884852	884909	884965	885022	885078	885135	885192	885248	885305
768	885361	885418	885474	885531	885587	885644	885700	885757	885813	885870
769	885926	885983	886039	886096	886152	886209	886265	886321	886378	886434
770	886491	886547	886604	886660	886716	886773	886829	886885	886942	886998
771	887054	887111	887167	887223	887280	887336	887392	887449	887505	887561
772	887617	887674	887730	887786	887842	887898	887955	888011	888068	888123
773	888179	888236	888292	888348	888404	888460	888516	888573	888629	888685
774	888741	888797	888853	888909	888965	889021	889077	889134	889190	889246
775	889302	889358	889414	889470	889526	889582	889638	889694	889750	889806
776	889862	889918	889974	890030	890086	890141	890197	890253	890309	890365
777	890421	890477	890533	890589	890644	890700	890756	890812	890868	890924
778	890980	891035	891091	891147	891203	891259	891314	891370	891426	891482
779	891537	891593	891649	891705	891760	891816	891872	891928	391983	892039
780	892095	892150	892206	892262	892317	892373	892429	892484	892540	892595
781	892651	892707	892762	892818	892873	892929	892985	893040	893096	893151
782	893207	893262	893318	893373	893429	893484	893540	893595	893651	893706
783	893762	893817	893873	893928	893984	894039	894094	894150	894205	894261
784	894316	894371	894427	894482	894538	894593	894648	894704	894759	894814
785	894870	894925	894980	895036	895091	895146	895201	895257	895312	895367
786	895423	895478	895533	895588	895643	895699	895754	895809	895864	895920
787	895975	896030	896085	896140	896195	896251	896306	896361	896416	896471
788	896526	896581	896636	896692	896747	896802	896857	896912	896967	897022
789	897077	897132	897187	897242	897297	897352	897407	897462	897517	897572
790	897627	897682	897737	897792	897847	897902	897657	898012	898067	898122
791	898176	898231	898286	898341	898396	898451	898506	898561	898615	898670
792	898725	898780	898835	898890	898944	898999	899054	899109	899164	899218
793	899273	899328	899383	899437	899492	899547	899602	899656	899711	899766
794	899820	899475	899930	899985	900039	900094	900149	900203	900258	900312
795	900367	900422	900476	900531	900586	900640	900695	900749	900804	900858
796	900913	900968	901022	901077	901131	901186	901240	901295	901349	901404
797	901458	901513	901567	901622	901676	901731	901785	901840	901894	901948
798	902003	902057	902112	902166	902221	902275	902329	902384	902438	902492
799	902547	902601	902655	902710	902764	902818	902873	902927	902981	903036
800	903090	903144	903198	903253	903307	903361	903416	903470	903524	903578
801	903632	903687	903741	903795	903849	903903	903958	904012	904066	904120
802	904174	904228	904283	904337	904391	904445	904499	904553	904607	904661
803	904715	904770	904824	904878	904931	904986	905040	905094	905148	905202
804	905256	905310	905364	905418	905472	905526	905580	905634	905688	905742
805	905796	905850	905904	905958	906012	906065	906119	906173	906227	906281
806	906335	906389	906443	906497	906550	906604	906658	906712	906766	906820
807	906873	906927	906981	907035	907089	907142	907196	907250	907304	907358
808	907411	907465	907519	907573	907626	907680	907734	907787	907841	907895
809	907948	908002	908056	908109	908163	908217	908270	908324	908378	908431
810	908485	908539	908592	908646	908699	908753	908807	908860	908914	908967
811	909021	909074	909128	909181	909235	909288	909342	909395	909449	909502
812	909556	909609	909663	909716	909770	909823	909877	909930	909984	910037
813	910090	910144	910197	910251	910304	910358	910411	910464	910518	910571
814	910624	910678	910731	910784	910838	910891	910944	910998	911051	911104
815	911158	911211	911264	911317	911371	911424	911477	911530	911584	911637
816	911690	911743	911797	911850	911903	911956	912009	912063	912116	912169
817	912222	912275	912328	912381	912435	912488	912541	912594	912647	912700
818	912753	912806	912859	912913	912966	913019	913072	913125	913178	913231
819	913284	913337	913390	913443	913496	913549	913602	913655	913708	913761
	0	1	2	3	4	5	6	7	8	9

No.	0	1	2	3	4	5	6	7	8	9
820	913814	913867	913920	913973	914026	914079	914131	914184	914237	914290
821	914343	914396	914449	914502	914555	914608	914660	914713	914766	914819
822	914872	914925	914977	915030	915083	915136	915189	915241	915294	915347
823	915400	915453	915505	915558	915611	915664	915716	915769	915822	915874
824	915927	915980	916033	916085	916138	916191	916243	916296	916349	916401
825	916454	916507	916559	916612	916664	916717	916770	916822	916875	916927
826	916980	917033	917085	917138	917190	917243	917295	917348	917400	917453
827	917505	917558	917610	917663	917715	917768	917820	917873	917925	917978
828	918030	918083	918135	918188	918240	918292	918345	918397	918450	918502
829	918555	918607	918659	918712	918764	918816	918869	918921	918973	919026
830	919078	919130	919183	919235	919287	919340	919392	919444	919496	919549
831	919601	919653	919705	919758	919810	919862	919914	919967	920019	920071
832	920123	920175	920228	920280	920332	920384	920436	920489	920541	920593
833	920645	920697	920749	920801	920853	920906	920958	921010	921062	921114
834	921166	921218	921270	921322	921374	921426	921478	921530	921582	921634
835	921686	921738	921790	921842	921894	921946	921998	922050	922102	922154
836	922206	922258	922310	922362	922414	922466	922518	922570	922622	922674
837	922725	922777	922829	922881	922933	922985	923037	923088	923140	923192
838	923244	923296	923348	923399	923451	923503	923555	923607	923658	923710
839	923762	923814	923865	923917	923969	924021	924072	924124	924176	924228
840	924279	924331	924383	924434	924486	924538	924589	924641	924693	924744
841	924796	924848	924899	924951	925002	925054	925106	925157	925209	925260
842	925312	925364	925415	925467	925518	925570	925621	925673	925724	925776
843	925828	925879	925931	925982	926034	926085	926137	926188	926239	926291
844	926342	926394	926445	926497	926548	926600	926651	926702	926754	926805
845	926857	926908	926959	927011	927062	927114	927165	927216	927268	927319
846	927370	927422	927473	927524	927576	927627	927678	927730	927781	927832
847	927883	927935	927986	928037	928088	928140	928191	928242	928293	928345
848	928396	928447	928498	928549	928601	928652	928703	928754	928805	928856
849	928908	928959	929010	929061	929112	929163	929214	929266	929317	929368
850	929419	929470	929521	929572	929623	929674	929725	929776	929827	929878
851	929930	929981	930032	930083	930134	930185	930236	930287	930338	930389
852	930440	930491	930541	930592	930643	930694	930745	930796	930847	930898
853	930949	931000	931051	931102	931153	931203	931254	931305	931356	931407
854	931458	931509	931560	931610	931661	931712	931763	931814	931864	931915
855	931966	932017	932068	932118	932169	932220	932271	932321	932372	932423
856	932474	932524	932575	932626	932677	932727	932778	932829	932879	932930
857	932981	933031	933082	933133	933183	933234	933285	933335	933386	933437
858	933487	933538	933588	933639	933690	933740	933791	933841	933892	933943
859	933993	934044	934094	934145	934195	934246	934296	934347	934397	934448
860	934498	934549	934599	934650	934700	934751	934801	934852	934902	934953
861	935003	935054	935104	935154	935205	935255	935306	935356	935406	935457
862	935507	935558	935608	935658	935709	935759	935809	935860	935910	935960
863	936011	936061	936111	936162	936212	936262	936313	936363	936413	936463
864	936514	936564	936614	936664	936715	936765	936815	936865	936916	936966
865	937016	937066	937116	937167	937217	937267	937317	937367	937418	937468
866	937518	937568	937618	937668	937718	937769	937819	937869	937919	937969
867	938019	938069	938119	938169	938219	938269	938319	938370	938420	938470
868	938520	938570	938620	938670	938720	938770	938820	938870	938920	938970
869	939020	939970	939120	939170	939220	939270	939319	939369	939419	939469
870	939519	939569	939619	939669	939719	939769	939819	939868	939918	939968
871	940018	940068	940118	940168	940218	940267	940317	940367	940417	940467
872	740516	940566	940616	940666	940716	940765	940815	940865	940915	940964
873	941014	941064	941114	941163	941213	941263	941313	941362	941412	941462
874	941511	941561	941611	941660	941710	941760	941809	941859	941909	941958
875	942008	942058	942107	942157	942206	942256	942306	942355	942405	942454
876	942504	942554	942603	942653	942702	942752	942801	942851	942900	942950
877	943000	943049	943099	943148	943198	943247	943297	943346	943396	943445
878	943494	943544	943593	943643	943692	943742	943791	943841	943890	943939
879	943989	944038	94[illegible]8	944137	944186	944236	944285	944335	944384	944433
	0	1	2	3	4	5	6	7	8	9

No.	0	1	2	3	4	5	6	7	8	9
880	944483	944532	944581	944631	944680	944729	944779	944828	944877	944927
881	944976	945025	945074	945124	945173	945222	945272	945321	945370	945419
882	945469	945518	945567	945616	945665	945715	945764	945813	945862	945911
883	945961	946010	946059	946108	946157	946207	946256	946305	946354	946403
884	946452	946501	946550	946600	946649	946698	946747	946796	946845	946894
885	946943	946992	947041	947090	947139	947189	947238	947287	947336	947385
886	947434	947483	947532	947581	947630	947679	947728	947777	947826	947875
887	947924	947973	948021	948070	948119	948168	948217	948266	948315	948364
888	948413	948462	948511	948560	948608	948657	948706	948755	948804	948853
889	948902	948951	948999	949048	949097	949146	949195	949244	949292	949341
890	949390	949439	949488	949536	949585	949634	949683	949731	949780	949829
891	949878	949926	949975	950024	950073	950121	950170	950219	950267	950316
892	950365	950413	950462	950511	950560	950608	950657	950705	950754	950803
893	950851	950900	950949	950997	951046	951095	951143	951192	951240	951289
894	951337	951386	951435	951483	951532	951580	951629	951677	951726	951774
895	951823	951872	951920	951969	952017	952066	952114	952163	952211	952259
896	952308	952356	952405	952453	952502	952550	952599	952647	952696	952744
897	952792	952841	952889	952938	952986	953034	953083	953131	953180	953228
898	953276	953325	953373	953421	953470	953518	953566	953615	953663	953711
899	953760	953808	953856	953905	953953	954001	954049	954098	954146	954194
900	954242	954291	954339	954387	954435	954484	954532	954580	954628	954677
901	954725	954773	954821	954869	954918	954966	955014	955062	955110	955158
902	955206	955255	955303	955351	955399	955447	955495	955543	955592	955640
903	955688	955736	955784	955832	955880	955928	955976	956024	956072	956120
904	956168	956216	956264	956312	956361	956409	956457	956505	956553	956601
905	956649	956697	956745	956792	956840	956888	956936	956984	957032	957080
906	957128	957176	957224	957272	957320	957368	957416	957464	957511	957559
907	957607	957655	957703	957751	957799	957847	957894	957942	957990	958038
908	958086	958134	958181	958229	958277	958325	958373	958420	958468	958516
909	958564	958612	958659	958707	958755	958803	958850	958898	958946	958994
910	959041	959089	959137	959184	959232	959280	959328	959375	959423	959471
911	959518	959566	959614	959661	959709	959757	959804	959852	959900	959947
912	959995	960042	960090	960138	960185	960233	960281	960328	960376	960423
913	960471	960518	960566	960613	960661	960709	960756	960804	960851	960899
914	960946	960994	961041	961089	961136	961184	961231	961279	961326	961374
915	961421	961469	961516	961563	961611	961658	961706	961753	961801	961848
916	961895	961943	961990	962038	962085	962132	962180	962227	962275	962322
917	962369	962417	962464	962511	962559	962606	962653	962701	962748	962795
918	962843	962890	962937	962985	963032	963079	963126	963174	963221	963268
919	963315	963363	963410	963457	963504	963552	963599	963646	963693	963741
920	963788	963835	963882	963929	963977	964024	964071	964118	964165	964212
921	964260	964307	964354	964401	964448	964495	964542	964590	964637	964684
922	964731	964778	964825	964872	964919	964966	965013	965060	965108	965155
923	965202	965249	965296	965343	965390	965437	965484	965531	965578	965625
924	965672	965719	965766	965813	965860	965907	965954	966001	966048	966095
925	966142	966189	966236	966283	966329	966376	966423	966470	966517	966564
926	966611	966658	966705	966752	966798	966845	966892	966939	966986	967033
927	967080	967127	967173	967220	967267	967314	967361	967408	967454	967501
928	967548	967595	967642	967688	967735	967782	967829	967875	967922	967969
929	968016	968062	968109	968156	968203	968249	968296	968343	968389	968436
930	968483	968530	968576	968623	968670	968716	968763	968810	968856	968903
931	968950	968996	969043	969090	969136	969183	969229	969276	969323	969369
932	969416	969462	969509	969556	969602	969649	969695	969742	969788	969835
933	969882	969928	969975	970021	970068	970114	970161	970207	970254	970300
934	970347	970393	970440	970486	970533	970579	970626	970672	970719	970765
935	970812	970858	970904	970951	970997	971044	971090	971137	971183	971229
936	971276	971322	971369	971415	971461	971508	971554	971600	971647	971693
937	971740	971786	971832	971879	971925	971971	972018	972064	972110	972156
938	972203	972249	972295	972342	972388	972434	972480	972527	972573	972619
939	972666	972712	972758	972804	972851	972897	972943	972989	973035	973082
	0	1	2	3	4	5	6	7	8	9

No.	0	1	2	3	4	5	6	7	8	9
940	973128	973174	973220	973266	973313	973359	973405	973451	973497	973543
941	973590	973636	973682	973728	973774	973820	973866	973913	973959	974005
942	974051	974097	974143	974189	974235	974281	974327	974373	974420	974466
943	974512	974558	974604	974650	974696	974742	974788	974834	974880	974926
944	974972	975018	975064	975110	975156	975202	975248	975294	975340	975386
945	975432	975478	975524	975570	975616	975661	975707	975753	975799	975845
946	975891	975937	975983	976029	976075	976121	976166	976212	976258	976304
947	976350	976396	976442	976487	976533	976579	976625	976671	976717	976762
948	976808	976854	976900	976946	976991	977037	977083	977129	977175	977220
949	977266	977312	977358	977403	977449	977495	977541	977586	977632	977678
950	977724	977769	977815	977861	977906	977952	977998	978043	978089	978135
951	978180	978226	978272	978317	978363	978409	978454	978500	978546	978591
952	978637	978683	978728	978774	978819	978865	978911	978956	979002	979047
953	979093	979138	979184	979230	979275	979321	979366	979412	979457	979503
954	979548	979594	979639	979685	979730	979776	979821	979867	979912	979958
955	980003	980049	980094	980140	980185	980231	980276	980322	980367	980412
956	980458	980503	980549	980594	980640	980685	980730	980776	980821	980867
957	980912	980957	981003	981048	981093	981139	981184	981229	981275	981320
958	981365	981411	981456	981501	981547	981592	981637	981683	981728	981773
959	981819	981864	981909	981954	982000	982045	982090	982135	982181	982226
960	982271	982316	982362	982407	982452	982497	982543	982588	982633	982678
961	982723	982769	982814	982859	982904	982949	982994	983040	983085	983130
962	983175	983220	983265	983310	983356	983401	983446	983491	983536	983581
963	983626	983671	983716	983762	983807	983852	983897	983942	983987	984032
964	984077	984122	984167	984212	984257	984302	984347	984392	984437	984482
965	984527	984572	984617	984662	984707	984752	984797	984842	984887	984932
966	984977	985022	985067	985112	985157	985202	985247	985292	985337	985382
967	985426	985471	985516	985561	985606	985651	985696	985741	985786	985830
968	985875	985920	985965	986010	986055	986100	986144	986189	986234	986279
969	986324	986369	986413	986458	986503	986548	986593	986637	986682	986727
970	986772	986816	986861	986906	986951	986995	987040	987085	987130	987174
971	987219	987264	987309	987353	987398	987443	987487	987532	987577	987622
972	987666	987711	987756	987800	987845	987890	987934	987979	988024	988068
973	988113	988157	988202	988247	988291	988336	988381	988425	988470	988514
974	988559	988603	988648	988693	908737	988782	988826	988871	988915	988960
975	989005	989049	989094	989138	989183	989227	989272	989316	989361	989405
976	989450	989494	989539	989583	989628	989672	989717	989761	989806	989850
977	989895	989939	989983	990028	990072	990117	990161	990206	990250	990294
978	990339	990383	990428	990472	990516	990561	990605	990650	990694	990738
979	990783	990827	990871	990916	990960	991004	991049	991093	991137	991182
980	991226	991270	991315	991359	991403	991448	991492	991536	991580	991625
981	991669	991713	991757	991802	991846	991890	991934	991979	992023	992067
982	992111	992156	992200	992244	992288	992333	992377	992421	992465	992509
983	992553	992598	992642	992686	992730	992774	992818	992863	992907	992951
984	992995	993039	993083	993127	993172	993216	993260	993304	993348	993392
985	993436	993480	993524	993568	993613	993657	993701	993745	993789	993833
986	993877	993921	993965	994009	994053	994097	994141	994185	994229	994273
987	994317	994361	994405	994449	994493	994537	994581	994625	994669	994713
988	994757	994801	994845	994889	994933	994977	995021	995064	995108	995152
989	995196	995240	995284	995328	995372	995416	995460	995504	995547	995591
990	995635	995679	995723	995767	995811	995854	995898	995942	995986	996030
991	996074	996117	996161	996205	996249	996293	996336	996380	996424	996468
992	996512	996555	996599	996643	996687	996730	996774	996818	996862	996905
993	996949	996993	997037	997080	997124	997168	997212	997255	997299	997343
994	997386	997430	997474	997517	997561	997605	997648	997692	997736	997779
995	997823	997867	997910	997954	997998	998041	998085	998128	998172	998216
996	998259	998303	998346	998390	998434	998477	998521	998564	998608	998652
997	998695	998739	998782	998826	998869	998913	998956	999000	999043	999087
998	999130	999174	999218	999261	999305	999348	999392	999435	999478	999522
999	999565	999609	999652	999696	999739	999783	999826	999870	999913	999957
	0	1	2	3	4	5	6	7	8	9

6 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang.	Secant	Co-sec.	M
0	9.019235	9.997614	9.021620	10.978380	10.002386	10.980765	60
1	9.020435	9.997601	9.022834	10.977166	10.002399	10.979565	59
2	9.021632	9.997588	9.024044	10.975956	10.002412	10.978368	58
3	9.022825	9.997574	9.025251	10.974749	10.002426	10.977175	57
4	9.024016	9.997561	9.026455	10.973545	10.002439	10.975984	56
5	9.025203	9.997547	9.027655	10.972345	10.002453	10.974797	55
6	9.026386	9.997534	9.028852	10.971148	10.002466	10.973614	54
7	9.027567	9.997520	9.030046	10.969954	10.002480	10.972433	53
8	9.028744	9.997507	9.031237	10.968763	10.002493	10.971256	52
9	9.029918	9.997493	9.032425	10.967575	10.002507	10.970082	51
10	9.031089	9.997480	9.033609	10.966391	10.002520	10.968911	50
11	9.032257	9.997466	9.034791	10.965209	10.002534	10.967743	49
12	9.033421	9.997452	9.035969	10.964031	10.002548	10.966579	48
13	9.034582	9.997439	9.037144	10.962856	10.002561	10.965418	47
14	9.035741	9.997425	9.038316	10.961684	10.002575	10.964259	46
15	9.036896	9.997411	9.039485	10.960515	10.002589	10.963104	45
16	9.038048	9.997397	9.040651	10.959349	10.002603	10.961952	44
17	9.039197	9.997383	9.041813	10.958187	10.002617	10.960803	43
18	9.040342	9.997369	9.042973	10.957027	10.002631	10.959658	42
19	9.041485	9.997355	9.044130	10.955870	10.002645	10.958515	41
20	9.042625	9.997341	9.045284	10.954716	10.002659	10.957375	40
21	9.043762	9.997327	9.046434	10.953566	10.002673	10.956238	39
22	9.044895	9.997313	9.047582	10.952418	10.002687	10.955105	38
23	9.046026	9.997299	9.048727	10.951273	10.002701	10.953974	37
24	9.047154	9.997285	9.049869	10.950131	10.002715	10.952846	36
25	9.048279	9.997271	9.051008	10.948992	10.002729	10.951721	35
26	9.049400	9.997257	9.052144	10.947856	10.002743	10.950600	34
27	9.050519	9.997242	9.053277	10.946723	10.002758	10.949481	33
28	9.051635	9.997228	9.054407	10.945593	10.002772	10.948365	32
29	9.052749	9.997214	9.055535	10.944465	10.002786	10.947251	31
30	9.053859	9.997199	9.056659	10.943341	10.002801	10.946141	30
31	9.054966	9.997185	9.057781	10.942219	10.002815	10.945034	29
32	9.056071	9.997170	9.058900	10.941100	10.002830	10.943929	28
33	9.057172	9.997156	9.060016	10.939984	10.002844	10.942828	27
34	9.058271	9.997141	9.061130	10.938870	10.002859	10.941729	26
35	9.059367	9.997127	9.062240	10.937760	10.002873	10.940633	25
36	9.060460	9.997112	9.063348	10.936652	10.002888	10.939540	24
37	9.061551	9.997098	9.064453	10.935547	10.002902	10.938449	23
38	9.062639	9.997083	9.065556	10.934444	10.002917	10.937361	22
39	9.063724	9.997068	9.066655	10.933345	10.002932	10.936276	21
40	9.064806	9.997053	9.067752	10.932248	10.002947	10.935194	20
41	9.065885	9.997039	9.068846	10.931154	10.002961	10.934115	19
42	9.066962	9.997024	9.069938	10.930062	10.002976	10.933038	18
43	9.068036	9.997009	9.071027	10.928973	10.002991	10.931964	17
44	9.069107	9.996994	9.072113	10.927887	10.003006	10.930893	16
45	9.070176	9.996979	9.073197	10.926803	10.003021	10.929824	15
46	9.071242	9.996964	9.074278	10.925722	10.003036	10.928758	14
47	9.072306	9.996949	9.075356	10.924644	10.003051	10.927694	13
48	9.073366	9.996934	9.076432	10.923568	10.003066	10.926634	12
49	9.074424	9.996919	9.077505	10.922495	10.003081	10.925576	11
50	9.075480	9.996904	9.078576	10.921424	10.003096	10.924520	10
51	9.076533	9.996889	9.079644	10.920350	10.003111	10.923467	9
52	9.077583	9.996874	9.080710	10.919290	10.003126	10.922417	8
53	9.078631	9.996858	9.081773	10.918227	10.003142	10.921369	7
54	9.079676	9.996843	9.082833	10.917167	10.003157	10.920324	6
55	9.080719	9.996828	9.083891	10.916109	10.003172	10.919281	5
56	9.081759	9.996812	9.084947	10.915053	10.003188	10.918241	4
57	9.082797	9.996797	9.086000	10.914000	10.003203	10.917203	3
58	9.083832	9.996782	9.087050	10.912950	10.003218	10.916168	2
59	9.084864	9.996766	9.088098	10.911902	10.003234	10.915136	1
60	9.085894	9.996751	9.089144	10.910856	10.003249	10.914106	0
M	Co-sine.	Sine.	Co-tang	Tang.	Co-sec.	Secant.	M

83 Degrees.

7 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang.	Secant	Co-sec.	M
0	9.085894	9.996751	9.089144	10.910856	10.003249	10.914106	60
1	9.086922	9.996735	9.090187	10.909813	10.003265	10.913078	59
2	9.087947	9.996720	9.091228	10.908772	10.003280	10.912053	58
3	9.088970	9.996704	9.092266	10.907734	10.003296	10.911030	57
4	9.089990	9.996688	9.093302	10.906698	10.003312	10.910010	56
5	9.091008	9.996673	9.094336	10.905664	10.003327	10.908992	55
6	9.092024	9.996657	9.095367	10.904633	10.003343	10.907976	54
7	9.093037	9.996641	9.096395	10.903605	10.003359	10.906963	53
8	9.094047	9.996625	9.097422	10.902578	10.003375	10.905953	52
9	9.095056	9.996610	9.098446	10.901554	10.003390	10.904944	51
10	9.096062	9.996594	9.099468	10.900532	10.003406	10.903938	50
11	9.097065	9.996578	9.100487	10.899513	10.003422	10.902935	49
12	9.098066	9.996562	9.101504	10.898496	10.003438	10.901934	48
13	9.099065	9.996546	9.102519	10.897481	10.003454	10.900935	47
14	9.100062	9.996530	9.103532	10.896468	10.003470	10.899938	46
15	9.101056	9.996514	9.104542	10.895458	10.003486	10.898944	45
16	9.102048	9.996498	9.105550	10.894450	10.003502	10.897952	44
17	9.103037	9.996482	9.106556	10.893444	10.003518	10.896963	43
18	9.104025	9.996465	9.107559	10.892441	10.003535	10.895975	42
19	9.105010	9.996449	9.108560	10.891440	10.003551	10.894990	41
20	9.105992	9.996433	9.109559	10.890441	10.003567	10.894008	40
21	9.106973	9.996417	9.110556	10.889444	10.003583	10.893027	39
22	9.107951	9.996400	9.111551	10.888449	10.003600	10.892049	38
23	9.108927	9.996384	9.112543	10.887457	10.003616	10.891073	37
24	9.109901	9.996368	9.113533	10.886467	10.003632	10.890099	36
25	9.110873	9.996351	9.114521	10.885479	10.003649	10.889127	35
26	9.111842	9.996335	9.115507	10.884493	10.003665	10.888158	34
27	9.112809	9.996318	9.116491	10.883509	10.003682	10.887191	33
28	9.113774	9.996302	9.117472	10.882528	10.003698	10.886226	32
29	9.114737	9.996285	9.118452	10.881548	10.003715	10.885263	31
30	9.115698	9.996269	6.119429	10.880571	10.003731	10.884302	30
31	9.116656	9.996252	9.120404	10.879596	10.003748	10.883344	29
32	9.117613	9.996235	9.121377	10.878623	10.003765	10.882387	28
33	9.118567	9.996219	9.122348	10.877652	10.003781	10.881433	27
34	9.119519	9.996202	9.123317	10.876683	10.003798	10.880481	26
35	9.120469	9.996185	9.124284	10.875716	10.003815	10.879531	25
36	9.121417	9.996168	9.125249	10.874751	10.003832	10.878583	24
37	9.122362	9.996151	9.126211	10.873789	10.003849	10.877638	23
38	9.123306	9.996134	9.127172	10.872828	10.003866	10.876694	22
39	9.124248	9.996117	9.128130	10.871870	10.003883	10.875752	21
40	9.125187	9.996100	9.129087	10.870913	10.003900	10.874813	20
41	9.126125	9.996083	9.130041	10.869959	10.003917	10.873875	19
42	9.127060	9.996066	9.130994	10.869006	10.003934	10.872940	18
43	9.127993	9.996049	9.131944	10.868056	10.003951	10.872007	17
44	9.128925	9.996032	9.132893	10.867107	10.003968	10.871075	16
45	9.129854	9.996015	9.133839	10.866161	10.003985	10.870146	15
46	9.130781	9.995998	9.134784	10.865216	10.004002	10.869219	14
47	9.131706	9.995980	9.135726	10.864274	10.004020	10.868294	13
48	9.132630	9.995963	9.136667	10.863333	10.004037	10.867370	12
49	9.133551	9.995946	9.137605	10.862395	10.004054	10.866449	11
50	9.134470	9.995928	9.138542	10.861458	10.004071	10.865530	10
51	9.135387	9.995911	9.139476	10.860524	10.004089	10.864613	9
52	9.136303	9.995894	9.140409	10.859591	10.004106	10.863697	8
53	9.137216	9.995876	9.141340	10.858660	10.004124	10.862784	7
54	9.138128	9.995859	9.142269	10.857731	10.004141	10.861872	6
55	9.139037	9.995841	9.143196	10.856804	10.004159	10.860963	5
56	9.139944	9.995823	9.144121	30.855879	10.004174	10.860056	4
57	9.140850	9.995806	9.145044	10.854956	10.004194	10.859150	3
58	9.141754	9.995788	9.145966	10.854034	10.004212	10.858246	2
59	9.142655	9.995771	9.146885	10.853115	10.004229	10.857345	1
60	9.143555	9.995753	9.147803	10.852197	10.004247	10.856445	0
M	Co-sine	Sine.	Cotang.	Tang.	Co-sec.	Secant.	M

82 Degrees.

8 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang.	Secant.	Co-sec.	M
0	9.143555	9.995753	9.147803	10.852197	10.004247	10.856445	60
1	9.144453	9.995735	9.148718	10.851282	10.004265	10.855547	59
2	9.145349	9.995717	9.149632	10.850368	10.004283	10.854651	58
3	9.146243	9.995699	9.150544	10.849456	10.004301	10.853757	57
4	9.147136	9.995681	9.151454	10.848546	10.004319	10.852864	56
5	9.148026	9.995664	9.152363	10.847637	10.004336	10.851974	55
6	9.148915	9.995646	9.153269	10.846731	10.004354	10.851085	54
7	9.149802	9.995628	9.154174	10.845826	10.004372	10.850198	53
8	9.150686	9.995610	9.155077	10.844923	10.004390	10.849314	52
9	9.151569	9.995591	9.155978	10.844022	10.004409	10.848431	51
10	9.152451	9.995573	9.156877	10.843123	10.004427	10.847549	50
11	9.153330	9.995555	9.157775	10.842225	10.004445	10.846670	49
12	9.154208	9.995537	9.158671	10.841329	10.004463	10.845792	48
13	9.155083	9.995519	9.159565	10.840435	10.004481	10.844917	47
14	9.155957	9.995501	9.160457	10.839543	10.004499	10.844043	46
15	9.156830	9.995482	9.161347	10.838653	10.004518	10.843170	45
16	9.157700	9.995464	9.162236	10.837764	10.004536	10.842300	44
17	9.158569	9.995446	9.163123	10.836877	10.004554	10.841431	43
18	9.159435	9.995427	9.164008	10.835992	10.004573	10.840565	42
19	9.160301	9.995409	9.164892	10.835108	10.004591	10.839699	41
20	9.161164	9.995390	9.165774	10.834226	10.004610	10.838836	40
21	9.162025	9.995372	9.166654	10.833346	10.004628	10.837975	39
22	9.162885	9.995353	9.167532	10.832468	10.004647	10.837115	38
23	9.163743	9.995334	9.168409	10.831591	10.004666	10.836257	37
24	9.164600	9.995316	9.169284	10.830716	10.004684	10.835400	36
25	9.165454	9.995297	9.170157	10.829843	10.004703	10.834546	35
26	9.166307	9.995278	9.171029	10.828971	10.004722	10.833693	34
27	9.167159	9.995260	9.171899	10.828101	10.004740	10.832841	33
28	9.168008	9.995241	9.172767	10.827233	10.004759	10.831992	32
29	9.168856	9.995222	9.173634	10.826366	10.004778	10.831144	31
30	9.169702	9.995203	9.174499	10.825501	10.004797	10.830298	30
31	9.170547	9.995184	9.175362	10.824638	10.004816	10.829453	29
32	9.171389	9.995165	9.176224	10.823776	10.004835	10.828611	28
33	9.172230	9.995146	9.177084	10.822916	10.004854	10.827770	27
34	9.173070	9.995127	9.177942	10.822058	10.004873	10.826930	26
35	9.173908	9.995108	9.178799	10.821201	10.004892	10.826092	25
36	9.174744	9.995089	9.179655	10.820345	10.004911	10.825256	24
37	9.175578	9.995070	9.180508	10.819490	10.004930	10.824422	23
38	9.176411	9.995051	9.181360	10.818640	10.004949	10.823589	22
39	9.177242	9.995032	9.182211	10.817789	10.004968	10.822758	21
40	9.178072	9.995013	9.183059	10.816941	10.004987	10.821928	20
41	9.178900	9.994993	9.183907	10.816093	10.005007	10.821100	19
42	9.179726	9.994974	9.184752	10.815248	10.005026	10.820274	18
43	9.180551	9.994955	9.185597	10.814403	10.005045	10.819449	17
44	9.181374	9.994935	9.186439	10.813561	10.005065	10.818626	16
45	9.182196	9.994916	9.187280	10.812720	10.005084	10.817804	15
46	9.183016	9.994896	9.188120	10.811880	10.005104	10.816984	14
47	9.183834	9.994877	9.188958	10.811042	10.005123	10.816166	13
48	9.184651	9.994857	9.189794	10.810206	10.005143	10.815349	12
49	9.185466	9.994838	9.190629	10.809371	10.005162	10.814534	11
50	9.186280	9.994818	9.191462	10.808538	10.005182	10.813720	10
51	9.187092	9.994798	9.192294	10.807706	10.005202	10.812908	9
52	9.187903	9.994779	9.193124	10.806876	10.005221	10.812097	8
53	9.188712	9.994759	9.193953	10.806047	10.005241	10.811288	7
54	9.189519	9.994739	9.194780	10.805220	10.005261	10.810481	6
55	9.190325	9.994720	9.195606	10.804394	10.005281	10.809675	5
56	9.191130	9.994700	9.196430	10.803570	10.005300	10.808870	4
57	9.191933	9.994680	9.197253	10.802747	10.005320	10.808067	3
58	9.192734	9.994660	9.198074	10.801926	10.005340	10.807266	2
59	9.193534	9.994640	9.198894	10.801106	10.005360	10.806466	1
60	9.194332	9.994620	9.199713	10.800287	10.005380	10.805668	0
M	Co-sine.	Sine.	Co-tang.	Tang.	Co-sec.	Secant.	M

81 Degrees.

9 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang.	Secant.	Co-sec.	M
0	9.194332	9.994620	9.199713	10.800287	10.005380	10.805668	60
1	9.195129	9.994600	9.200529	10.799471	10.005400	10.804871	59
2	9.195925	9.994580	9.201345	10.798655	10.005420	10.804075	58
3	9.196719	9.994560	9.202159	10.797841	10.005440	10.803281	57
4	9.197511	9.994540	9.202971	10.797029	10.005460	10.802489	56
5	9.198302	9.994519	9.203782	10.796218	10.005481	10.801698	55
6	9.199091	9.994499	9.204592	10.795408	10.005501	10.800909	54
7	9.199879	9.994479	9.205400	10.794600	10.005521	10.800121	53
8	9.200666	9.994459	9.206207	10.793793	10.005541	10.799334	52
9	9.201451	9.994438	9.207013	10.792987	10.005562	10.798549	51
10	9.202234	9.994418	9.207817	10.792183	10.005582	10.797766	50
11	9.203017	9.994398	9.208619	10.791381	10.005602	10.796983	49
12	9.203797	9.994377	9.209420	10.790580	10.005623	10.796203	48
13	9.204577	9.994357	9.210220	10.789780	10.005643	10.795423	47
14	9.205354	9.994336	9.211018	10.788982	10.005664	10.794646	46
15	9.206131	9.994316	9.211815	10.788185	10.005684	10.793869	45
16	9.206906	9.994295	9.212611	10.787389	10.005705	10.793094	44
17	9.207679	9.994274	9.213405	10.786595	10.005726	10.792321	43
18	9.208452	9.994254	9.214198	10.785802	10.005746	10.791548	42
19	9.209222	9.994233	9.214989	10.785011	10.005767	10.790778	41
20	9.209992	9.994212	9.215780	10.784220	10.005788	10.790008	40
21	9.210760	9.994191	9.216568	10.783432	10.005809	10.789240	39
22	9.211526	9.994171	9.217356	10.782644	10.005829	10.788474	38
23	9.212291	9.994150	9.218142	10.781858	10.005850	10.787709	37
24	9.213055	9.994129	9.218926	10.781074	10.005871	10.786945	36
25	9.213818	9.994108	9.219710	10.780290	10.005892	10.786182	35
26	9.214579	9.994087	9.220492	10.779508	10.005913	10.785421	34
27	9.215338	9.994066	9.221272	10.778728	10.005934	10.784662	33
28	9.216097	9.994045	9.222052	10.777948	10.005955	10.783903	32
29	9.216854	9.994024	9.222830	10.777170	10.005976	10.783146	31
30	9.217609	9.994003	9.223607	10.776393	10.005997	10.782391	30
31	9.218363	9.993982	9.224382	10.775618	10.006018	10.781637	29
32	9.219116	9.993960	9.225156	10.774844	10.006040	10.780884	28
33	9.219868	9.993939	9.225929	10.774071	10.006061	10.780132	27
34	9.220618	9.993918	9.226700	10.773300	10.006082	10.779382	26
35	9.221367	9.993897	9.227471	10.772529	10.006103	10.778633	25
36	9.222115	9.993875	9.228239	10.771761	10.006125	10.777885	24
37	9.222861	9.993854	9.229007	10.770993	10.006146	10.777139	23
38	9.223606	9.993832	9.229773	10.770227	10.006168	10.776394	22
39	9.224349	9.993811	9.230539	10.769461	10.006189	10.775651	21
40	9.225092	9.993789	9.231302	10.768698	10.006211	10.774908	20
41	9.225833	9.993768	9.232065	10.767935	10.006232	10.774167	19
42	9.226573	9.993746	9.232826	10.767174	10.006254	10.773427	18
43	9.227311	9.993725	9.233586	10.766414	10.006275	10.772689	17
44	9.228048	9.993703	9.234345	10.765655	10.006297	10.771952	16
45	9.228784	9.993681	9.235103	10.764897	10.006319	10.771216	15
46	9.229518	9.993660	9.235859	10.764141	10.006340	10.770482	14
47	9.230252	9.993638	9.236614	10.763386	10.006362	10.769748	13
48	9.230984	9.993616	9.237368	10.762632	10.006384	10.769016	12
49	9.231715	9.993594	9.238120	10.761880	10.006406	10.768285	11
50	9.232444	9.993572	9.238872	10.761128	10.006428	10.767556	10
51	9.233172	9.993550	9.239622	10.760378	10.006450	10.766828	9
52	9.233899	9.993528	9.240371	10.759629	10.006472	10.766101	8
53	9.234625	9.993506	9.241118	10.758882	10.006494	10.765375	7
54	9.235349	9.993484	9.241865	10.758135	10.006516	10.764651	6
55	9.236073	9.993462	9.242610	10.757390	10.006538	10.763927	5
56	9.236795	9.993440	9.243354	10.756646	10.006560	10.763205	4
57	9.237515	9.993418	9.244097	10.755903	10.006582	10.762485	3
58	9.238235	9.993396	9.244839	10.755161	10.006604	10.761765	2
59	9.238953	9.993374	9.245579	10.754421	10.006626	10.761047	1
60	9.239670	9.993351	9.246319	10.753681	10.006649	10.760330	0
M	Co sine.	Sine.	Co-tang	Tang.	Co-sec.	Secant	M

80 Degrees.

10 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang.	Secant.	Co-sec.	M
0	9.239670	9.993351	9.246319	10.753681	10.006649	10.760330	60
1	9.240386	9.993329	9.247057	10.752943	10.006671	10.759614	59
2	9.241101	9.993307	9.247794	10.752206	10.006693	10.758899	58
3	9.241814	9.993285	9.248530	10.751470	10.006715	10.758186	57
4	9.242526	9.993262	9.249264	10.750736	10.006738	10.757474	56
5	9.243237	9.993240	9.249998	10.750002	10.006760	10.756763	55
6	9.243947	9.993217	9.250730	10.749270	10.006783	10.756053	54
7	9.244656	9.993195	9.251461	10.748539	10.006805	10.755344	53
8	9.245363	9.993172	9.252191	10.747809	10.006828	10.754637	52
9	9.246069	9.993149	9.252920	10.747080	10.006851	10.753931	51
10	9.246775	9.993127	9.253648	10.746352	10.006873	10.753225	50
11	9.247478	9.993104	9.254374	10.745626	10.006896	10.752522	49
12	9.248181	9.993081	9.255100	10.744900	10.006919	10.751819	48
13	9.248883	9.993059	9.255824	10.744176	10.006941	10.751117	47
14	9.249583	9.993036	9.256547	10.743453	10.006964	10.750417	46
15	9.250282	9.993013	9.257269	10.742731	10.006987	10.749718	45
16	9.250980	9.992990	9.257990	10.742010	10.007010	10.749020	44
17	9.251677	9.992967	9.258710	10.741290	10.007033	10.748323	43
18	9.252373	9.992944	9.259429	10.740571	10.007056	10.747627	42
19	9.253067	9.992921	9.260146	10.739854	10.007079	10.746933	41
20	9.253761	9.992898	9.260863	10.739137	10.007102	10.746239	40
21	9.254453	9.992875	9.261578	10.738422	10.007125	10.745547	39
22	9.255144	9.992852	9.262292	10.737708	10.007148	10.744856	38
23	9.255834	9.992829	9.263005	10.736995	10.007171	10.744166	37
24	9.256523	9.992806	9.263717	10.736283	10.007194	10.743477	36
25	9.257211	9.992783	9.264428	10.735572	10.007217	10.742789	35
26	9.257898	9.992759	9.265138	10.734862	10.007241	10.742102	34
27	9.258583	9.992736	9.265847	10.734153	10.007264	10.741417	33
28	9.259268	9.992713	9.266555	10.733445	10.007287	10.740732	32
29	9.259951	9.992690	9.267261	10.732739	10.007311	10.740049	31
30	9.260633	9.992666	9.267967	10.732033	10.007334	10.739367	30
31	9.261314	9.992643	9.268671	10.731329	10.007357	10.738686	29
32	9.261994	9.992619	9.269375	10.730625	10.007381	10.738006	28
33	9.262673	9.992596	9.270077	10.729923	10.007404	10.737327	27
34	9.263351	9.992572	9.270779	10.729221	10.007428	10.736649	26
35	9.264027	9.992549	9.271479	10.728521	10.007451	10.735973	25
36	9.264703	9.992525	9.272178	10.727821	10.007475	10.735297	24
37	9.265377	9.992501	9.272876	10.727124	10.007499	10.734623	23
38	9.266051	9.992478	9.273573	10.726427	10.007522	10.733949	22
39	9.266723	9.992454	9.274269	10.725731	10.007546	10.733277	21
40	9.267395	9.992430	9.274964	10.725036	10.007570	10.732605	20
41	9.268065	9.992406	9.275658	10.724342	10.007594	10.731935	19
42	9.268734	9.992382	9.276351	10.723649	10.007618	10.731266	18
43	9.269402	9.992358	9.277043	10.722957	10.007642	10.730598	17
44	9.270069	9.992335	9.277734	10.722266	10.007665	10.729931	16
45	9.270735	9.992311	9.278424	10.721576	10.007689	10.729265	15
46	9.271400	9.992287	9.279113	10.720887	10.007713	10.728600	14
47	9.272064	9.992263	9.279801	10.720199	10.007737	10.727936	13
48	9.272726	9.992239	9.280488	10.719512	10.007761	10.727274	12
49	9.273388	9.992214	9.281174	10.718826	10.007786	10.726612	11
50	9.274049	9.992190	9.281858	10.718142	10.007810	10.725951	10
51	9.274708	9.992166	9.282542	10.717458	10.007834	10.725292	9
52	9.275367	9.992142	9.283225	10.716775	10.007858	10.724633	8
53	9.276025	9.992118	9.283907	10.716093	10.007882	10.723975	7
54	9.276681	9.992093	9.284588	10.715412	10.007907	10.723319	6
55	9.277337	9.992069	9.285268	10.714732	10.007931	10.722663	5
56	9.277991	9.992044	9.285947	10.714053	10.007956	10.722009	4
57	9.278645	9.992020	9.286624	10.713376	10.007980	10.721355	3
58	9.279297	9.991996	9.287301	10.712699	10.008004	10.720703	2
59	9.279948	9.991971	9.287977	10.712023	10.008029	10.720052	1
60	9.280599	9.991947	9.288652	10.711348	10.008053	10.719401	0
M	Co-sine.	Sine.	Co-tang.	Tang.	Co-sec.	Secant.	M

79 Degrees.

11 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang	Secant.	Co-sec.	M
0	9.280599	9.991947	9.288652	10.711348	10.008053	10.719401	60
1	9.281248	9.991922	9.289326	10.710674	10.008078	10.718752	59
2	9.281897	9.991897	9.289999	10.710001	10.008103	10.718103	58
3	9.282544	9.991873	9.290671	10.709329	10.008127	10.717456	57
4	9.283190	9.991848	9.291342	10.708658	10.008152	10.716810	56
5	9.283836	9.991823	9.292013	10.707987	10.008177	10.716164	55
6	9.284480	9.991799	9.292682	10.707318	10.008201	10.715520	54
7	9.285124	9.991774	9.293350	10.706650	10.008226	10.714876	53
8	9.285766	9.991749	9.294017	10.705983	10.008251	10.714234	52
9	9.286408	9.991724	9.294684	10.705316	10.008276	10.713592	51
10	9.287048	9.991699	9.295349	10.704651	10.008301	10.712952	50
11	9.287688	9.991674	9.296013	10.703987	10.008326	10.712312	49
12	9.288326	9.991649	3.296677	10.703323	10.008351	10.711674	48
13	9.288964	9.991624	9.297339	10.702661	10.008376	10.711036	47
14	9.289600	9.991599	9.298001	10.701999	10.008401	10.710400	46
15	9.290236	9.991574	9.298662	10.701338	10.008426	10.709764	45
16	9.290870	9.991549	9.299322	10.700678	10.008451	10.709130	44
17	9.291504	9.991524	9.299980	10.700020	10.008476	10.708496	43
18	9 292137	9.991498	9.300638	10.699362	10.008502	10.707863	42
19	9.292768	9.991473	9.301295	10.698705	10.008527	10.707232	41
20	9.293399	9.991448	9.301951	10.698049	10.008552	10.706601	40
21	9.294029	9.991422	9,302607	10.697393	10.008578	10.705971	39
22	9.294658	9.991397	9.303261	10.696739	10.008603	10.705342	38
23	9.295286	9.991372	9.303914	10.696086	10.008628	10.704714	37
24	9.295913	9.991346	9.304567	10.695433	10.008654	10.70408[illegible]	36
25	9.296539	9.991321	9.305218	10.694782	10.008679	10.703461	35
26	9.297164	9.991295	9.305869	10.694131	10.008705	10.702836	34
27	9.297788	9.991270	9.306519	10.693481	10.008730	10.702212	33
28	9.298412	9.991244	9.307168	10.692832	10.008756	10.701588	32
29	9.299034	9.991218	9.307815	10.692185	10.008782	10.700966	31
30	9.299655	9.991193	9.308463	10.691537	10.008807	10.700345	30
31	9.300276	9 991167	9.309109	10.690891	10.008833	10.699724	29
32	9.300895	9.991141	9.309754	10.690246	10.008859	10.699105	28
33	9.301514	9.991115	9.310398	10.689602	10.008885	10.698486	27
34	9.302132	9.991090	9.311042	10.688958	10.008910	10.697868	26
35	9.302748	9.991064	9.311685	10 688315	10.008936	10.697252	25
36	9.303364	9.991038	9.312327	10.687673	10.008962	10.696636	24
37	9.303979	9.991012	9.312967	10.687033	10.008988	10.696021	23
38	9.304593	9.990986	9.313608	10.686392	10.009014	10.695407	22
39	9.305207	9.990960	9.314247	10.685753	10.009040	10.694793	21
40	9.305819	9.990934	9.314885	10.685115	10.009066	10.694181	20
41	9.306430	9.990908	9.315523	10.684477	10.009092	10 693570	19
42	9.307041	9.990882	9.316159	10.683841	10.009118	10.692959	18
43	9.307650	9.990855	9.316795	10.683205	10.009145	10.692350	17
44	9.308259	9.990829	9.317430	10.682570	10.009171	10.691741	16
45	9.308867	9.990803	9.318064	10.681936	10.009197	10.691133	15
46	9.309474	9.990777	9.318697	10.681303	10.009223	10.690526	14
47	9.310080	9.990750	9.319329	10.680671	10.009250	10.689920	13
48	9.310685	9.990724	9.319961	10.680039	10.009276	10.689315	12
49	9.311289	9.990697	9.320592	10.679408	10.009303	10.688711	11
50	9.311893	9.990671	9.321222	10.678778	10.009329	10.688107	10
51	9.312495	9.990645	9.321851	10.678149	10.009355	10 687505	9
52	9.313097	9.990618	9.322479	10.677521	10.009382	10.686903	8
53	9.313698	9.990591	9.323106	10.676894	10.009409	10.686302	7
54	9.314297	9.990565	9.323733	10.676267	10.009435	10.685703	6
55	9.314897	9.990538	9.324358	10.675642	10.009462	10.685103	5
56	9.315495	9.990511	9.324983	10.675017	10.009489	10.684505	4
57	9.316092	9.990485	9.325607	10.674393	10.009515	10.683908	3
58	9.316689	9.990458	9.326231	10.673769	10.009542	10 683311	2
59	9.317284	9.990431	9.326853	10.673147	10.009569	10.682716	1
60	9.317879	9.990404	9.327475	10.672525	10.009596	10.682121	0
M	Co-sine.	Sine.	Co-tang.	Tang.	Co-sec.	Secant.	M

78 Degrees.

12 Degrees.

M	Sine.	Co-sine	Tang.	Co-tang.	Secant.	Co-sec.	M
0	9.317879	9.990404	9.327474	10.672526	10.009596	10.682121	60
1	9.318473	9.990378	9.328095	10.671905	10.009622	10.681527	59
2	9.319066	9.990351	9.328715	10.671285	10.009649	10.680934	58
3	9.319658	9.990324	9.329334	10.670666	10.009676	10.680342	57
4	9.320249	9.990297	9.329953	10.670047	10.009703	10.679751	56
5	9.320840	9.990270	9.330570	10.669430	10.009730	10.679160	55
6	9.321430	9.990243	9.331187	10.668813	10.009757	10.678570	54
7	9.322019	9.990215	9.331803	10.668197	10.009785	10.677981	53
8	9.322607	9.990188	9.332418	10.667582	10.009812	10.677393	52
9	9.323194	9.990161	9.333033	10.666967	10.009839	10.676806	51
10	9.323780	9.990134	9.333646	10.666354	10.009866	10.676220	50
11	9.324366	9.990107	9.334259	10.665741	10.009893	10.675634	49
12	9.324950	9.990079	9.334871	10.665129	10.009921	10.675050	48
13	9.325534	9.990052	9.335482	10.664518	10.009948	10.674466	47
14	9.326117	9.990025	9.336093	10.663907	10.009975	10.673883	46
15	9.326700	9.989997	9.336702	10.663298	10.010003	10.673300	45
16	9.327281	9.989970	9.337311	10.662689	10.010030	10.672719	44
17	9.327862	9.989942	9.337919	10.662081	10.010058	10.672138	43
18	9.328442	9.989915	9.338527	10.661473	10.010085	10.671558	42
19	9.329021	9.989887	9.339133	10.660867	10.010113	10.670979	41
20	9.329599	9.989860	9.339739	10.660261	10.010140	10.670401	40
21	9.330176	9.989832	9.340344	10.659656	10.010168	10.669824	39
22	9.330753	9.989804	9.340948	10.659052	10.010196	10.669247	38
23	9.331329	9.989777	9.341552	10.658448	10.010223	10.668671	37
24	9.331903	9.989749	9.342155	10.657845	10.010251	10.668097	36
25	9.332478	9.989721	9.342757	10.657243	10.010279	10.667522	35
26	9.333051	9.989693	9.343358	10.656642	10.010307	10.666949	34
27	9.333624	9.989665	9.343958	10.656042	10.010335	10.666376	33
28	9.334195	9.989637	9.344558	10.655442	10.010363	10.665805	32
29	9.334767	9.989610	9.345157	10.654843	10.010390	10.665233	31
30	9.335337	9.989582	9.345755	10.654245	10.010418	10.664663	30
31	9.335906	9.989553	9.346353	10.653647	10.010447	10.664094	29
32	9.336475	9.989525	9.346949	10.653051	10.010475	10.663525	28
33	9.337043	9.989497	9.347545	10.652455	10.010503	10.662957	27
34	9.337610	9.989469	9.348141	10.651859	10.010531	10.662390	26
35	9.338176	9.989441	9.348735	10.651265	10.010559	10.661824	25
36	9.338742	9.989413	9.349329	10.650671	10.010587	10.661258	24
37	9.339307	9.989385	9.349922	10.650078	10.010615	10.660693	23
38	9.339871	9.989356	9.350514	10.649486	10.010644	10.660129	22
39	9.340434	9.989328	9.351106	10.648894	10.010672	10.659566	21
40	9.340996	9.989300	9.351697	10.648303	10.010700	10.659004	20
41	9.341558	9.989271	9.352287	10.647713	10.010729	10.658442	19
42	9.342119	9.989243	9.352876	10.647124	10.010757	10.657881	18
43	9.342679	9.989214	9.353465	10.646535	10.010786	10.657321	17
44	9.343239	9.989186	9.354053	10.645947	10.010814	10.656761	16
45	9.343797	9.989157	9.354640	10.645360	10.010843	10.656203	15
46	9.344355	9.989128	9.355227	10.644773	10.010872	10.655645	14
47	9.344912	9.989100	9.355813	10.644187	10.010900	10.655088	13
48	9.345469	9.989071	9.356398	10.643602	10.010929	10.654531	12
49	9.346024	9.989042	9.356982	10.643018	10.010958	10.653976	11
50	9.346579	9.989014	9.357566	10.642434	10.010986	10.653421	10
51	9.347134	9.988985	9.358140	10.641851	10.011015	10.652866	9
52	9.347687	9.988956	9.358731	10.641269	10.011044	10.652313	8
53	9.348240	9.988927	9.359313	10.640687	10.011073	10.651760	7
54	9.348792	9.988898	9.359893	10.640107	10.011102	10.651208	6
55	9.349343	9.988869	9.360474	10.639526	10.011131	10.650657	5
56	9.349893	9.988840	9.361053	10.638947	10.011160	10.650107	4
57	9.350443	9.988811	9.361632	10.638368	10.011189	10.649557	3
58	9.350992	9.988782	9.362210	10.637790	10.011218	10.649008	2
59	9.351540	9.988753	9.362787	10.637213	10.011247	10.648460	1
60	9.352088	9.988724	9.363364	10.636636	10.011276	10.647912	0
M	Co-sine	Sine.	Co-tang.	Tang.	Co-sec.	Secant.	M

77 Degrees.

13 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang.	Secant.	Co-sec.	M
0	9.352088	9.988724	.363364	10.636636	10.011276	10.647912	60
1	9.352635	9.988695	9.363940	10.636060	10.011305	10.647365	59
2	9.353181	9.988666	9.364515	10.635485	10.011334	10.646819	58
3	9.353726	9.988636	9.365090	10.634910	10.011364	10.646274	57
4	9.354271	9.988607	9.365664	10.634336	10.011393	10.645729	56
5	9.354815	9.988578	9.366237	10.633763	10.011422	10.645185	55
6	9.355358	9.988548	9.366810	10.633190	10.011452	10.644642	54
7	9.355901	9.988519	9.367382	10.632618	10.011481	10.644099	53
8	9.356443	9.988489	9.367953	10.632047	10.011511	10.643557	52
9	9.356984	9.988460	9.368524	10.631476	10.011540	10.643016	51
10	9.357524	9.988430	9.369094	10.630906	10.011570	10.642476	50
11	9.358064	9.988401	9.369663	10.630337	10.011599	10.641936	49
12	9.358603	9.988371	9.370232	10.629768	10.011629	10.641397	48
13	9.359141	9.988342	9.370799	10.629201	10.011658	10.640859	47
14	9.359678	9.988312	9.371367	10.628633	10.011688	10.640322	46
15	9.360215	9.988282	9.371933	10.628067	10.011718	10.639785	45
16	9.360752	9.988252	9.372499	10.627501	10.011748	10.639248	44
17	9.361287	9.988223	9.373064	10.626936	10.011777	10.638713	43
18	9.361822	9.988193	9.373629	10.626371	10.011807	10.638178	42
19	9.362356	9.988163	9.374193	10.625807	10.011837	10.637644	41
20	9.362889	9.988133	9.374756	10.625244	10.011867	10.637111	40
21	9.363422	9.988103	9.375319	10.624681	10.011897	10.636578	39
22	9.363954	9.988073	9.375881	10.624119	10.011927	10.636046	38
23	9.364485	9.988043	9.376442	10.623558	10.011957	10.635515	37
24	9.365016	9.988013	9.377003	10.622997	10.011987	10.634984	36
25	9.365546	9.987983	9.377563	10.622437	10.012017	10.634454	35
26	9.366075	9.987953	9.378122	10.621878	10.012047	10.633925	34
27	9.366604	9.987922	9.378681	10.621319	10.012078	10.633396	33
28	9.367131	9.987892	9.379239	10.620761	10.012108	10.632869	32
29	9.367659	9.987862	9.379797	10.620203	10.012138	10.632341	31
30	9.368185	9.987832	9.380354	10.619646	10.012168	10.631815	30
31	9.368711	9.987801	9.380910	10.619090	10.012199	10.631289	29
32	9.369236	9.987771	9.381466	10.618534	10.012229	10.630764	28
33	9.369761	9.987740	9.382020	10.617980	10.012260	10.630239	27
34	9.370285	9.987710	9.382575	10.617425	10.012290	10.629715	26
35	9.370808	9.987679	9.383129	10.616871	10.012321	10.629192	25
36	9.371330	9.987649	9.383682	10.616318	10.012351	10.628670	24
37	9.371852	9.987618	9.384234	10.615766	10.012382	10.628148	23
38	9.372373	9.987588	9.384786	10.615214	10.012412	10.627627	22
39	9.372894	9.987557	9.385337	10.614663	10.012443	10.627106	21
40	9.373414	9.987526	9.385888	10.614112	10.012474	10.626586	20
41	9.373933	9.987496	9.386438	10.613562	10.012504	10.626067	19
42	9.374452	9.987465	9.386987	10.613013	10.012535	10.625548	18
43	9.374970	9.987434	9.387536	10.612464	10.012566	10.625030	17
44	9.375487	9.987403	9.388084	10.611916	10.012597	10.624513	16
45	9.376003	9.987372	9.388631	10.611369	10.012628	10.623997	15
46	9.376519	9.987341	9.389178	10.610822	10.012659	10.623481	14
47	9.377035	9.987310	9.389724	10.610276	10.012690	10.622965	13
48	9.377549	9.987279	9.390270	10.609730	10.012721	10.622451	12
49	9.378063	9.987248	9.390815	10.609185	10.012752	10.621937	11
50	9.378577	9.987217	9.391360	10.608640	10.012783	10.621423	10
51	9.379089	9.987186	9.391903	10.608097	10.012814	10.620911	9
52	9.379601	9.987155	9.392447	10.607553	10.012845	10.620399	8
53	9.380113	9.987124	9.392989	10.607011	10.012876	10.619887	7
54	9.380624	9.987092	9.393531	10.606469	10.012908	10.619376	6
55	9.381134	9.987061	9.394073	10.605927	10.012939	10.618866	5
56	9.381643	9.987030	9.394614	10.605386	10.012970	10.618357	4
57	9.382152	9.986998	9.395154	10.604846	10.013002	10.617848	3
58	9.382661	9.986967	9.395694	10.604306	10.013033	10.617339	2
59	9.383168	9.986936	9.396233	10.603767	10.013064	10.616832	1
60	9.383675	9.986904	9.396771	10.603229	10.013096	10.616325	0
M	Co-sine.	Sine.	Co-tang.	Tang.	Co-sec.	Secant.	M

76 Degrees.

14 Degree.

M	Sine.	Co-sine	Tang.	Co-tang	Secant.	Co-sec.	M
0	9.383675	9.986904	9.396771	10.603229	10.013096	10.616325	60
1	9.384182	9.986873	9.397309	10.602691	10.013127	10.615818	59
2	9.384687	9.986841	9.397846	10.602154	10.013159	10.615313	58
3	9.385192	9.986809	9.398383	10.601617	10.013191	10.614808	57
4	9.385697	9.986778	9.398919	10.601081	10.013222	10.614303	56
5	9.386201	9.986746	9.399455	10.600545	10.013254	10.613799	55
6	9.386704	9.986714	9.399990	10.600010	10.013286	10.613296	54
7	9.387207	9.986683	9.400524	10.599476	10.013317	10.612793	53
8	9.387709	9.986651	9.401058	10.598942	10.013349	10.612291	52
9	9.388210	9.986619	9.401591	10.598409	10.013381	10.611790	51
10	9.388711	9.986587	9.402124	10.597876	10.013413	10.611289	50
11	9.389211	9.986555	9.402656	10.597344	10.013445	10.610789	49
12	9.389711	9.986523	9.403187	10.596813	10.013477	10.610289	48
13	9.390210	9.986491	9.403718	10.596282	10.013509	10.609790	47
14	9.390708	9.986459	9.404249	10.595751	10.013541	10.609292	46
15	9.391206	9.986427	9.404778	10.595222	10.013573	10.608794	45
16	9.391703	9.986395	9.405308	10.594692	10.013605	10.608297	44
17	9.392199	9.986363	9.405836	10.594164	10.013637	10.607801	43
18	9.392695	9.986331	9.406364	10.593636	10.013669	10.607305	42
19	9.393191	9.986299	9.406892	10.593108	10.013701	10.606810	41
20	9.393685	9.986266	9.407419	10.592581	10.013734	10.606315	40
21	9.394179	9.986234	9.407945	10.592055	10.013766	10.605821	39
22	9.394673	9.986202	9.408471	10.591529	10.013798	10.605327	38
23	9.395166	9.986169	9.408997	10.591003	10.013831	10.604834	37
24	9.395658	9.986137	9.409521	10.590479	10.013863	10.604342	36
25	9.396150	9.986104	9.410045	10.589955	10.013896	10.603850	35
26	9.396641	9.986072	9.410569	10.589431	10.013928	10.603359	34
27	9.397132	9.986039	9.411092	10.588908	10.013961	10.602868	33
28	9.397621	9.986007	9.411615	10.588385	10.013993	10.602379	32
29	9.398111	9.985974	9.412137	10.587863	10.014026	10.601889	31
30	9.398600	9.985942	9.412658	10.587342	10.014058	10.601400	30
31	9.399088	9.985909	9.413179	10.586821	10.014091	10.600912	29
32	9.399575	9.985876	9.413699	10.586301	10.014124	10.600425	28
33	9.400062	9.985843	9.414219	10.585781	10.014157	10.599938	27
34	9.400549	9.985811	9.414738	10.585262	10.014189	10.599451	26
35	9.401035	9.985778	9.415257	10.584743	10.014222	10.598965	25
36	9.401520	9.985745	9.415775	10.584225	10.014255	10.598480	24
37	9.402005	9.985712	9.416293	10.583707	10.014288	10.597995	23
38	9.402489	9.985679	9.416810	10.583190	10.014321	10.597511	22
39	9.402972	9.985646	9.417326	10.582674	10.014354	10.597028	21
40	9.403455	9.985613	9.417842	10.582158	10.014387	10.596545	20
41	9.403938	9.985580	9.418358	10.581642	10.014420	10.596062	19
42	9.404420	9.985547	9.418873	10.581127	10.014453	10.595580	18
43	9.404901	9.985514	9.419387	10.580613	10.014486	10.595099	17
44	9.405382	9.985480	9.419901	10.580099	10.014520	10.594618	16
45	9.405862	9.985447	9.420415	10.579585	10.014553	10.594138	15
46	9.406341	9.985414	9.420927	10.579073	10.014586	10.593659	14
47	9.406820	9.985381	9.421440	10.578560	10.014619	10.593180	13
48	9.407299	9.985347	9.421952	10.578048	10.014653	10.592701	12
49	9.407777	9.985314	9.422463	10.577537	10.014686	10.592223	11
50	9.408254	9.985280	9.422974	10.577026	10.014720	10.591746	10
51	9.408731	9.985247	9.423484	10.576516	10.014753	10.591269	9
52	9.409207	9.985213	9.423993	10.576007	10.014787	10.590793	8
53	9.409682	9.985180	9.424503	10.575497	10.014820	10.590318	7
54	9.410157	9.985146	9.425011	10.574989	10.014854	10.589843	6
55	9.410632	9.985113	9.425519	10.574481	10.014887	10.589368	5
56	9.411106	9.985079	9.426027	10.573973	10.014921	10.588894	4
57	9.411579	9.985045	9.426534	10.573466	10.014955	10.588421	3
58	9.412052	9.985011	9.427041	10.572959	10.014989	10.587948	2
59	9.412524	9.984978	9.427547	10.572453	10.015021	10.587476	1
60	9.412996	9.984944	9.428052	10.571948	10.015056	10.587004	0
M	Co-sine.	Sine.	Co-tang.	Tang.	Co-sec.	Secant.	M

75 Degrees.

15 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang.	Secant.	Co-sec.	M
0	9.412996	9.984944	9.428052	10.571948	10.015056	10.587004	60
1	9.413467	9.984910	9.428557	10.571443	10.015090	10.586533	59
2	9.413938	9.984876	9.429062	10.570938	10.015124	10.586062	58
3	9.414408	9.984842	9.429566	10.570434	10.015158	10.585592	57
4	9.414878	9.984808	9.430070	10.569930	10.015192	10.585122	56
5	9.415347	9.984774	9.430573	10.569427	10.015226	10.584653	55
6	9.415815	9.984740	9.431075	10.568925	10.015260	10.584185	54
7	9.416283	9.984706	9.431577	10.568423	10.015294	10.583717	53
8	9.416751	9.984672	9.432079	10.567921	10.015328	10.583249	52
9	9.417217	9.984638	9.432580	10.567420	10.015362	10.582783	51
10	9.417684	9.984603	9.433080	10.566920	10.015397	10.582316	50
11	9.418150	9.984569	9.433580	10.566420	10.015431	10.581850	49
12	9.418615	9.984535	9.434080	10.565920	10.015465	10.581385	48
13	9.419079	9.984500	9.434579	10.565421	10.015500	10.580921	47
14	9.419544	9.984466	9.435078	10.564922	10.015534	10.580456	46
15	9.420007	9.984432	9.435576	10.564424	10.015568	10.579993	45
16	9.420470	9.984397	9.436073	10.563927	10.015603	10.579530	44
17	9.420933	9.984363	9.436570	10.563430	10.015637	10.579067	43
18	9.421395	9.984328	9.437067	10.562933	10.015672	10.578605	42
19	9.421857	9.984294	9.437563	10.562437	10.015706	10.578143	41
20	9.422318	9.984259	9.438059	10.561941	10.015741	10.577682	40
21	9.422778	9.984224	9.438554	10.561446	10.015776	10.577222	39
22	9.423238	9.984190	9.439048	10.560952	10.015810	10.576762	38
23	9.423697	9.984155	9.439543	10.560457	10.015845	10.576303	37
24	9.424156	9.984120	9.440036	10.559964	10.015880	10.575844	36
25	9.424615	9.984085	9.440529	10.559471	10.015915	10.575385	35
26	9.425073	9.984050	9.441022	10.558978	10.015950	10.574927	34
27	9.425530	9.984015	9.441514	10.558486	10.015985	10.574470	33
28	9.425987	9.983981	9.442006	10.557994	10.016019	10.574013	32
29	9.426443	9.983946	9.442497	10.557503	10.016054	10.573557	31
30	9.426899	9.983911	9.442988	10.557012	10.016089	10.573101	30
31	9.427354	9.983875	9.443479	10.556521	10.016125	10.572646	29
32	9.427809	9.983840	9.443968	10.556032	10.016160	10.572191	28
33	9.428263	9.983805	9.444458	10.555542	10.016195	10.571737	27
34	9.428717	9.983770	9.444947	10.555053	10.016230	10.571283	26
35	9.429170	9.983735	9.445435	10.554565	10.016265	10.570830	25
36	9.429623	9.983700	9.445923	10.554077	10.016300	10.570377	24
37	9.430075	9.983664	9.446411	10.553589	10.016336	10.569925	23
38	9.430527	9.983629	9.446898	10.553102	10.016371	10.569473	22
39	9.430978	9.983594	9.447384	10.552616	10.016406	10.569022	21
40	9.431429	9.983558	9.447870	10.552130	10.016442	10.568571	20
41	9.431879	9.983523	9.448356	10.551644	10.016477	10.568121	19
42	9.432329	9.983487	9.448841	10.551159	10.016513	10.567671	18
43	9.432778	9.983452	9.449326	10.550674	10.016548	10.567222	17
44	9.433226	9.983416	9.449810	10.550190	10.016584	10.566774	16
45	9.433675	9.983381	9.450294	10.549706	10.016619	10.566325	15
46	9.434122	9.983345	9.450777	10.549223	10.016655	10.565878	14
47	9.434569	9.983309	9.451260	10.548740	10.016691	10.565431	13
48	9.435016	9.983273	9.451743	10.548257	10.016727	10.564984	12
49	9.435462	9.983238	9.452225	10.547775	10.016762	10.564538	11
50	9.435908	9.983202	9.452706	10.547294	10.016798	10.564092	10
51	9.436353	9.983166	9.453187	10.546813	10.016834	10.563647	9
52	9.436798	9.983130	9.453668	10.546332	10.016870	10.563202	8
53	9.437242	9.983094	9.454148	10.545852	10.016906	10.562758	7
54	9.437686	9.983058	9.454628	10.545372	10.016942	10.562314	6
55	9.438129	9.983022	9.455107	10.544893	10.016978	10.561871	5
56	9.438572	9.982986	9.455586	10.544414	10.017014	10.561428	4
57	9.439014	9.982950	9.456064	10.543936	10.017050	10.560986	3
58	9.439456	9.982914	9.456542	10.543458	10.017086	10.560544	2
59	9.439897	9.982878	9.457019	10.542981	10.017122	10.560103	1
60	9.440338	9.982842	9.457496	10.542504	10.017158	10.559662	0
M	Co-sine.	Sine.	Co-tang.	Tang.	Co-sec.	Secant.	M

74 Degrees.

16 Degrees.

M	Sine.	Co-sine	Tang.	Co-tang.	Secant	Co-sec.	M
0	9.440338	9.982842	9.457496	10.542504	10.017158	10.559662	60
1	9.440778	9.982805	9.457973	10.542027	10.017195	10.559222	59
2	9.441218	9.982769	9.458449	10.541551	10.017231	10.558782	58
3	9.441658	9.982733	9.458925	10.541075	10.017267	10.558342	57
4	9.442096	9.982696	9.459400	10.540600	10.017304	10.557904	56
5	9.442535	9.982660	9.459875	10.540125	10.017340	10.557465	55
6	9.442973	9.982624	9.460349	10.539651	10.017376	10.557027	54
7	9.443410	9.982587	9.460823	10.539177	10.017413	10.556590	53
8	9.443847	9.982551	9.461297	10.538703	10.017449	10.556153	52
9	9.444284	9.982514	9.461770	10.538230	10.017486	10.555716	51
10	9.444720	9.982477	9.462242	10.537758	10.017523	10.555280	50
11	9.445155	9.982441	9.462714	10.537286	10.017559	10.554845	49
12	9.445590	9.982404	9.463186	10.536814	10.017596	10.554410	48
13	9.446025	9.982367	9.463658	10.536342	10.017633	10.553975	47
14	9.446459	9.982331	9.464128	10.535872	10.017669	10.553541	46
15	9.446893	9.982294	9.464599	10.535401	10.017706	10.553107	45
16	9.447326	9.982257	9.465069	10.534931	10.017743	10.552674	44
17	9.447759	9.982220	9.465539	10.534461	10.017780	10.552241	43
18	9.448191	9.982183	9.466008	10.533992	10.017817	10.551809	42
19	9.448623	9.982146	9.466476	10.533524	10.017854	10.551377	41
20	9.449054	9.982109	9.466945	10.533055	10.017891	10.550946	40
21	9.449485	9.982072	9.467413	10.532587	10.017928	10.550515	39
22	9.449915	9.982035	9.467880	10.532120	10.017965	10.550085	38
23	9.450345	9.981998	9.468347	10.531653	10.018002	10.549655	37
24	9.450775	9.981961	9.468814	10.531186	10.018039	10.549225	36
25	9.451204	9.981924	9.469280	10.530720	10.018076	10.548796	35
26	9.451632	9.981886	9.469746	10.530254	10.018114	10.548368	34
27	9.452060	9.981849	9.470211	10.529789	10.018151	10.547940	33
28	9.452488	9.981812	9.470676	10.529324	10.018188	10.547512	32
29	9.452915	9.981774	9.471141	10.528859	10.018226	10.547085	31
30	9.453342	9.981737	9.471605	10.528395	10.018263	10.546658	30
31	9.453768	9.981700	9.472068	10.527932	10.018300	10.546232	29
32	9.454194	9.981662	9.472532	10.527468	10.018338	10.545806	28
33	9.454619	9.981625	9.472995	10.527005	10.018375	10.545381	27
34	9.455044	9.981587	9.473457	10.526543	10.018413	10.544956	26
35	9.455469	9.981549	9.473919	10.526081	10.018451	10.544531	25
36	9.455893	9.981512	9.474381	10.525619	10.018488	10.544107	24
37	9.456316	9.981474	9.474842	10.525158	10.018526	10.543684	23
38	9.456739	9.981436	9.475303	10.524697	10.018564	10.543261	22
39	9.457162	9.981399	9.475763	10.524237	10.018601	10.542838	21
40	9.457584	9.981361	9.476223	10.523777	10.018639	10.542416	20
41	9.458006	9.981323	9.476683	10.523317	10.018677	10.541994	19
42	9.458427	9.981285	9.477142	10.522858	10.018715	10.541573	18
43	9.458848	9.981247	9.477601	10.522399	10.018753	10.541152	17
44	9.459268	9.981209	9.478059	10.521941	10.018791	10.540732	16
45	9.459688	9.981171	9.478517	10.521483	10.018829	10.540312	15
46	9.460108	9.981133	9.478975	10.521025	10.018867	10.539892	14
47	9.460527	9.981095	9.479432	10.520568	10.018905	10.539473	13
48	9.460946	9.981057	9.479889	10.520111	10.018943	10.539054	12
49	9.461364	9.981019	9.480345	10.519655	10.018981	10.538636	11
50	9.461782	9.980981	9.480801	10.519199	10.019019	10.538218	10
51	9.462199	9.980942	9.481257	10.518743	10.019058	10.537801	9
52	9.462616	9.980904	9.481712	10.518288	10.019096	10.537384	8
53	9.463032	9.980866	9.482167	10.517833	10.019134	10.536968	7
54	9.463448	9.980827	9.482621	10.517379	10.019173	10.536552	6
55	9.463864	9.980789	9.483075	10.516925	10.019211	10.536136	5
56	9.464279	9.980750	9.483529	10.516471	10.019250	10.535721	4
57	9.464994	9.980712	9.484982	10.516018	10.019288	10.535306	3
58	9.465108	9.980673	9.484435	10.515565	10.019327	10.534892	2
59	9.465522	9.980635	9.484887	10.515113	10.019365	10.534478	1
60	9.465935	9.980596	9.485339	10.514661	10.019404	10.534065	0
M	Co-sine	Sine.	Co-tang.	Tang.	Co-sec.	Secant.	M

73 Degrees.

17 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang.	Secant.	Co-sec.	M
0	9.465935	9.980596	9.485339	10.514661	10.019404	10.534065	60
1	9.466348	9.980558	9.485791	10.514209	10.019442	10.533652	59
2	9.466761	9.980519	9.486242	10.513758	10.019481	10.533239	58
3	9.467173	9.980480	9.486693	10.513307	10.019520	10.532827	57
4	9.467585	9.980442	9.487143	10.512857	10.019558	10.532415	56
5	9.467996	9.980403	9.487593	10.512407	10.019597	10.532004	55
6	9.468407	9.980364	9.488043	10.511957	10.019636	10.531593	54
7	9.468817	9.980325	9.488492	10.511508	10.019675	10.531183	53
8	9.469227	9.980286	9.488941	10.511059	10.019714	10.530773	52
9	9.469637	9.980247	9.489390	10.510610	10.019753	10.530363	51
10	9.470046	9.980208	9.489838	10.510162	10.019792	10.529954	50
11	9.470455	9.980169	9.490286	10.509714	10.019831	10.529545	49
12	9.470863	9.980130	9.490733	10.509267	10.019870	10.529137	48
13	9.471271	9.980091	9.491180	10.508820	10.019909	10.528729	47
14	9.471679	9.980052	9.491627	10.508373	10.019948	10.528321	46
15	9.472086	9.980012	9.492073	10.507927	10.019988	10.527914	45
16	9.472492	9.979973	9.492519	10.507481	10.020027	10.527508	44
17	9.472898	9.979934	9.492965	10.507035	10.020066	10.527102	43
18	9.473304	9.979895	9.493410	10.506590	10.020105	10.526696	42
19	9.473710	9.979855	9.493854	10.506146	10.020145	10.526290	41
20	9.474115	9.979816	9.494299	10.505701	10.020184	10.525885	40
21	9.474519	9.979776	9.494743	10.505257	10.020224	10.525481	39
22	9.474923	9.979737	9.495186	10.504814	10.020263	10.525077	38
23	9.475327	9.979697	9.495630	10.504370	10.020303	10.524673	37
24	9.475730	9.979658	9.496073	10.503927	10.020342	10.524270	36
25	9.476133	9.979618	9.496515	10.503485	10.020382	10.523867	35
26	9.476536	9.979579	9.496957	10.503043	10.020421	10.523464	34
27	9.476938	9.979539	9.497399	10.502601	10.020461	10.523062	33
28	9.477340	9.979499	9.497841	10.502159	10.020501	10.522660	32
29	9.477741	9.979459	9.498282	10.501718	10.020541	10.522259	31
30	9.478142	9.979420	9.498722	10.501278	10.020580	10.521858	30
31	9.478542	9.979380	9.499163	10.500837	10.020620	10.521458	29
32	9.478942	9.979340	9.499603	10.500397	10.020660	10.521058	28
33	9.479342	9.979300	9.500042	10.499958	10.020700	10.520658	27
34	9.479741	9.979260	9.500481	10.499519	10.020740	10.520259	26
35	9.480140	9.979220	9.500920	10.499080	10.020780	10.519860	25
36	9.480539	9.979180	9.501359	10.498641	10.020820	10.519461	24
37	9.480937	9.979140	9.501797	10.498203	10.020860	10.519063	23
38	9.481334	9.979100	9.502235	10.497765	10.020900	10.518666	22
39	9.481731	9.979059	9.502672	10.497328	10.020941	10.518269	21
40	9.482128	9.979019	9.503109	10.496891	10.020981	10.517872	20
41	9.482525	9.978979	9.503546	10.496454	10.021021	10.517475	19
42	9.482921	9.978939	9.503982	10.496018	10.021061	10.517079	18
43	9.483316	9.978898	9.504418	10.495582	10.021102	10.516684	17
44	9.483712	9.978858	9.504854	10.495146	10.021142	10.516288	16
45	9.484107	9.978817	9.505289	10.494711	10.021183	10.515893	15
46	9.484501	9.978777	9.505724	10.494276	10.021223	10.515499	14
47	9.484895	9.978737	9.506159	10.493841	10.021263	10.515105	13
48	9.485289	9.978696	9.506593	10.493407	10.021304	10.514711	12
49	9.485682	9.978655	9.507027	10.492973	10.021345	10.514318	11
50	9.486075	9.978615	9.507460	10.492540	10.021385	10.513925	10
51	9.486467	9.978574	9.507893	10.492107	10.021426	10.513533	9
52	9.486860	9.978533	9.508326	10.491674	10.021467	10.513140	8
53	9.487251	9.978493	9.508759	10.491241	10.021507	10.512749	7
54	9.487643	9.978452	9.509191	10.490809	10.021548	10.512357	6
55	9.488034	9.978411	9.509622	10.490378	10.021589	10.511966	5
56	9.488424	9.978370	9.510054	10.489946	10.021630	10.511576	4
57	9.488814	9.978329	9.510485	10.489515	10.021671	10.511186	3
58	9.489204	9.978288	9.510916	10.489084	10.021712	10.510796	2
59	9.489593	9.978247	9.511346	10.488654	10.021753	10.510407	1
60	9.489982	9.978206	9.511776	10.488224	10.021794	10.510018	0
M	Co-sine	Sine.	Co-tang.	Tang.	Co-sec	Secant	M

72 Degrees.

18 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang.	Secant.	Co-sec.	M
0	9.489982	9.978206	9.511776	10.488224	10.021794	10.510018	60
1	9.490371	9.978165	9.512206	10.487794	10.021835	10.509629	59
2	9.490759	9.978124	9.512635	10.487365	10.021876	10.509241	58
3	9.491147	9.978083	9.513064	10.486936	10.021917	10.508853	57
4	9.491535	9.978042	9.513493	10.486507	10.021958	10.508465	56
5	9.491922	9.978001	9.513921	10.486079	10.021999	10.508078	55
6	9.492308	9.977959	9.514349	10.485651	10.022041	10.507692	54
7	9.492695	9.977918	9.514777	10.485223	10.022082	10.507305	53
8	9.493081	9.977877	9.515204	10.484796	10.022123	10.506919	52
9	9.493466	9.977835	9.515631	10.484369	10.022165	10.506534	51
10	9.493851	9.977794	9.516057	10.483943	10.022206	10.506149	50
11	9.494236	9.977752	9.516484	10.483516	10.022248	10.505764	49
12	9.494621	9.977711	9.516910	10.483090	10.022289	10.505379	48
13	9.495005	9.977669	9.517335	10.482665	10.022331	10.504995	47
14	9.495388	9.977628	9.517761	10.482239	10.022372	10.504612	46
15	9.495772	9.977586	9.518185	10.481815	10.022414	10.504228	45
16	9.496154	9.977544	9.518610	10.481390	10.022456	10.503846	44
17	9.496537	9.977503	9.519034	10.480966	10.022497	10.503463	43
18	9.496919	9.977461	9.519458	10.480542	10.022539	10.503081	42
19	9.497301	9.977419	9.519882	10.480118	10.022581	10.502699	41
20	9.497682	9.977377	9.520305	10.479695	10.022623	10.502318	40
21	9.498064	9.977335	9.520728	10.479272	10.022665	10.501936	39
22	9.498444	9.977293	9.521151	10.478849	10.022701	10.501556	38
23	9.498825	9.977251	9.521573	10.478427	10.022749	10.501175	37
24	9.499204	9.977209	9.521995	10.478005	10.022791	10.500796	36
25	9.499584	9.977167	9.522417	10.477583	10.022833	10.500416	35
26	9.499963	9.977125	9.522838	10.477162	10.022875	10.500037	34
27	9.500342	9.977083	9.523259	10.476741	10.022917	10.499658	33
28	9.500721	9.977041	9.523680	10.476320	10.022959	10.499279	32
29	9.501099	9.976999	9.524100	10.475900	10.023001	10.498901	31
30	9.501476	9.976957	9.524520	10.475480	10.023043	10.498524	30
31	9.501854	9.976914	9.524939	10.475061	10.023086	10.498146	29
32	9.502231	9.976872	9.525359	10.474641	10.023128	10.497769	28
33	9.502607	9.976830	9.525778	10.474222	10.023170	10.497393	27
34	9.502984	9.976787	9.526197	10.473803	10.023213	10.497016	26
35	9.503360	9.976745	9.526615	10.473385	10.023255	10.496640	25
36	9.503735	9.976702	9.527033	10.472967	10.023298	10.496265	24
37	9.504110	9.976660	9.527451	10.472549	10.023340	10.495890	23
38	9.504485	9.976617	9.527868	10.472132	10.023383	10.495515	22
39	9.504860	9.976574	9.528285	10.471715	10.023426	10.495140	21
40	9.505234	9.976532	9.528702	10.471298	10.023468	10.494766	20
41	9.505608	9.976489	9.529119	10.470881	10.023511	10.494392	19
42	9.505981	9.976446	9.529535	10.470465	10.023554	10.494019	18
43	9.506354	9.976404	9.529950	10.470050	10.023596	10.493646	17
44	9.506727	9.976361	9.530366	10.469634	10.023639	10.493273	16
45	9.507099	9.976318	9.530781	10.469219	10.023682	10.492901	15
46	9.507471	9.976275	9.531196	10.468804	10.023725	10.492529	14
47	9.507843	9.976232	9.531611	10.468389	10.023768	10.492157	13
48	9.508214	9.976189	9.532025	10.467975	10.023811	10.491786	12
49	9.508585	9.976146	9.532439	10.467561	10.023854	10.491415	11
50	9.508956	9.976103	9.532853	10.467147	10.023897	10.491044	10
51	9.509326	9.976060	9.533266	10.466734	10.023940	10.490674	9
52	9.509696	9.976017	9.533679	10.466321	10.023983	10.490304	8
53	9.510065	9.975974	9.534092	10.465908	10.024026	10.489935	7
54	9.510434	9.975930	9.534504	10.465496	10.024070	10.489566	6
55	9.510803	9.975887	9.534916	10.465084	10.024113	10.489197	5
56	9.511172	9.975844	9.535328	10.464672	10.024156	10.488828	4
57	9.511540	9.975800	9.535739	10.464261	10.024200	10.488460	3
58	9.511907	9.975757	9.536150	10.463850	10.024243	10.488093	2
59	9.512275	9.975714	9.536561	10.463439	10.024286	10.487725	1
60	9.512642	9.975670	9.536972	10.463028	10.024330	10.487358	0
M	Co-sine.	Sine.	Co-tang.	Tang.	Co-sec.	Secant.	M

71 Degrees.

19 Degrees.

M	Sine	Co-sine.	Tang.	Co-tang.	Secant.	Co-sec.	M
0	9.512642	9.975670	9.536972	10.463028	10.024330	10.487358	60
1	9.513009	9.975627	9.537382	10.462618	10.024373	10.486991	59
2	9.513375	9.975583	9.537792	10.462208	10.024417	10.486625	58
3	9.513741	9.975539	9.538202	10.461798	10.024461	10.486259	57
4	9.514107	9.975496	9.538611	10.461389	10.024504	10.485893	56
5	9.514472	9.975452	9.539020	10.460980	10.024548	10.485528	55
6	9.514837	9.975408	9.539429	10.460571	10.024592	10.485163	54
7	9.515202	9.975365	9.539837	10.460163	10.024635	10.484798	53
8	9.515566	9.975321	9.540245	10.459755	10.024679	10.484434	52
9	9.515930	9.975277	9.540653	10.459347	10.024723	10.484070	51
10	9.516294	9.975233	9.541061	10.458939	10.024767	10.483706	50
11	9.516657	9.975189	9.541468	10.458532	10.024811	10.483343	49
12	9.517020	9.975145	9.541875	10.458125	10.024855	10.482980	48
13	9.517382	9.975101	9.542281	10.457719	10.024899	10.482618	47
14	9.517745	9.975057	9.542688	10.457312	10.024943	10.482255	46
15	9.518107	9.975013	9.543094	10.456906	10.024987	10.481893	45
16	9.518468	9.974969	9.543499	10.456501	10.025031	10.481532	44
17	9.518829	9.974925	9.543905	10.456095	10.025075	10.481171	43
18	9.519190	9.974880	9.544310	10.455690	10.025120	10.480810	42
19	9.519551	9.974836	9.544715	10.455285	10.025164	10.480449	41
20	9.519911	9.974792	9.545119	10.454881	10.025208	10.480089	40
21	9.520271	9.974748	9.545524	10.454476	10.025252	10.479729	39
22	9.520631	9.974703	9.545928	10.454072	10.025297	10.479369	38
23	9.520990	9.974659	9.546331	10.453669	10.025341	10.479010	37
24	9.521349	9.974614	9.546735	10.453265	10.025386	10.478651	36
25	9.521707	9.974570	9.547138	10.452862	10.025430	10.478293	35
26	9.522066	9.974525	9.547540	10.452460	10.025475	10.477934	34
27	9.522424	9.974481	9.547943	10.452057	10.025519	10.477576	33
28	9.522781	9.974436	9.548345	10.451655	10.025564	10.477219	32
29	9.523138	9.974391	9.548747	10.451253	10.025609	10.476862	31
30	9.523495	9.974347	9.549149	10.450851	10.025653	10.476505	30
31	9.523852	9.974302	9.549550	10.450450	10.025698	10.476148	29
32	9.524208	9.974257	9.549951	10.450049	10.025743	10.475792	28
33	9.524564	9.974212	9.550352	10.449648	10.025788	10.475436	27
34	9.524920	9.974167	9.550752	10.449248	10.025833	10.475080	26
35	9.525275	9.974122	9.551152	10.448848	10.025878	10.474725	25
36	9.525630	9.974077	9.551552	10.448448	10.025923	10.474370	24
37	9.525984	9.974032	9.551952	10.448048	10.025968	10.474016	23
38	9.526339	9.973987	9.552351	10.447649	10.026013	10.473661	22
39	9.526693	9.973942	9.552750	10.447250	10.026058	10.473307	21
40	9.527046	9.973897	9.553149	10.446851	10.026103	10.472954	20
41	9.527400	9.973852	9.553548	10.446452	10.026148	10.472600	19
42	9.527753	9.973807	9.553946	10.446054	10.026193	10.472247	18
43	9.528105	9.973761	9.554344	10.445656	10.026239	10.471895	17
44	9.528458	9.973716	9.554741	10.445259	10.026284	10.471542	16
45	9.528810	9.973671	9.555139	10.444861	10.026329	10.471190	15
46	9.529161	9.973625	9.555536	10.444464	10.026375	10.470839	14
47	9.529513	9.973580	9.555933	10.444067	10.026420	10.470487	13
48	9.529864	9.973535	9.556329	10.443671	10.026465	10.470136	12
49	9.530215	9.973489	9.556725	10.443275	10.026511	10.469785	11
50	9.530565	9.973444	9.557121	10.442879	10.026556	10.469435	10
51	9.530915	9.973398	9.557517	10.442483	10.026602	10.469085	9
52	9.531265	9.973352	9.557913	10.442087	10.026648	10.468735	8
53	9.531614	9.973307	9.558308	10.441692	10.026693	10.468386	7
54	9.531963	9.973261	9.558702	10.441298	10.026739	10.468037	6
55	9.532312	9.973215	9.559097	10.440903	10.026785	10.467688	5
56	9.532661	9.973169	9.559491	10.440509	10.026831	10.467339	4
57	9.533009	9.973124	9.559885	10.440115	10.026876	10.466991	3
58	9.533357	9.973078	9.560279	10.439721	10.026922	10.466643	2
59	9.533704	9.973032	9.560673	10.439327	10.026968	10.466296	1
60	9.534052	9.972986	9.561066	10.438934	10.027014	10.465948	0
M	Co-sine	Sine.	Co-tang.	Tang.	Co-sec.	Secant.	M

70 Degrees.

20 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang	Secant	Co-sec	M
0	9.534052	9.972986	9.561066	10.438934	10.027014	10.465948	60
1	9.534399	9.972940	9.561459	10.438541	10.027060	10.465601	59
2	9.534745	9.972894	9.561851	10.438149	10.027106	10.465255	58
3	9.535092	9.972848	9.562244	10.437756	10.027152	10.464908	57
4	9.535438	9.972802	9.562636	10.437364	10.027198	10.464562	56
5	9.535783	9.972755	9.563028	10.436972	10.027245	10.464217	55
6	9.536129	9.972709	9.563419	10.436581	10.027291	10.463871	54
7	9.536474	9.972663	9.563811	10.436189	10.027337	10.463526	53
8	9.536818	9.972617	9.564202	10.435798	10.027383	10.463182	52
9	9.537163	9.972570	9.564592	10.435408	10.027430	10.462837	51
10	9.537507	9.972524	9.564983	10.435017	10.027476	10.462493	50
11	9.537851	9.972478	9.565373	10.434627	10.027522	10.462149	49
12	9.538194	9.972431	9.565763	10.434237	10.027569	10.461806	48
13	9.538538	9.972385	9.566153	10.433847	10.027615	10.461462	47
14	9.538880	9.972338	9.566542	10.433458	10.027662	10.461120	46
15	9.539223	9.972291	9.566932	10.433068	10.027709	10.460777	45
16	9.539565	9.972245	9.567320	10.432680	10.027755	10.460435	44
17	9.539907	9.972198	9.567709	10.432291	10.027802	10.460093	43
18	9.540249	9.972151	9.568098	10.431902	10.027849	10.459751	42
19	9.540590	9.972105	9.568486	10.431514	10.027895	10.459410	41
20	9.540931	9.972058	9.568873	10.431127	10.027942	10.459069	40
21	9.541272	9.972011	9.569261	10.430739	10.027989	10.458728	39
22	9.541613	9.971964	9.569648	10.430352	10.028036	10.458387	38
23	9.541953	9.971917	9.570035	10.429965	10.028083	10.458047	37
24	9.542293	9.971870	9.570422	10.429578	10.028130	10.457707	36
25	9.542632	9.971823	9.570809	10.429191	10.028177	10.457368	35
26	9.542971	9.971776	9.571195	10.428805	10.028224	10.457029	34
27	9.543310	9.971729	9.571581	10.428419	10.028271	10.456690	33
28	9.543649	9.971682	9.571967	10.428033	10.028318	10.456351	32
29	9.543987	9.971635	9.572352	10.427648	10.028365	10.456013	31
30	9.544325	9.971588	9.572738	10.427262	10.028412	10.455675	30
31	9.544663	9.971540	9.573123	10.426877	10.028460	10.455337	29
32	9.545000	9.971493	9.573507	10.426493	10.028507	10.455000	28
33	9.545338	9.971446	9.573892	10.426108	10.028554	10.454662	27
34	9.545674	9.971398	9.574276	10.425724	10.028602	10.454326	26
35	9.546011	9.971351	9.574660	10.425340	10.028649	10.453989	25
36	9.546347	9.971303	9.575044	10.424956	10.028697	10.453653	24
37	9.546683	9.971256	9.575427	10.424573	10.028744	10.453317	23
38	9.547019	9.971208	9.575810	10.424190	10.028792	10.452981	22
39	9.547354	9.971161	9.576193	10.423807	10.028839	10.452646	21
40	9.547689	9.971113	9.576576	10.423424	10.028887	10.452311	20
41	9.548024	9.971066	9.576958	10.423042	10.028934	10.451976	19
42	9.548359	9.971018	9.577341	10.422659	10.028982	10.451641	18
43	9.548693	9.970970	9.577723	10.422277	10.029030	10.451307	17
44	9.549027	9.970922	9.578104	10.421896	10.029078	10.450973	16
45	9.549360	9.970874	9.578486	10.421514	10.029126	10.450640	15
46	9.549693	9.970827	9.578867	10.421133	10.029173	10.450307	14
47	9.550026	9.970779	9.579248	10.420752	10.029221	10.449974	13
48	9.550359	9.970731	9.579629	10.420371	10.029269	10.449641	12
49	9.550692	9.970683	9.580009	10.419991	10.029317	10.449308	11
50	9.551024	9.970635	9.580389	10.419611	10.029365	10.448976	10
51	9.551356	9.970586	9.580769	10.419231	10.029414	10.448644	9
52	9.551687	9.970538	9.581149	10.418851	10.029462	10.448313	8
53	9.552018	9.970490	9.581528	10.418472	10.029510	10.447982	7
54	9.552349	9.970442	9.581907	10.418093	10.029558	10.447651	6
55	9.552680	9.970394	9.582286	10.417714	10.029606	10.447320	5
56	9.553010	9.970345	9.582665	10.417335	10.029655	10.446990	4
57	9.553341	9.970297	9.583043	10.416957	10.029703	10.446659	3
58	9.553670	9.970249	9.583422	10.416578	10.029751	10.446330	2
59	9.554000	9.970200	9.583800	10.416200	10.029800	10.446000	1
60	9.554329	9.970152	9.584177	10.415823	10.029848	10.445671	0
M	Co-sine.	Sine.	Co-tang	Tang.	Co-sec.	Secant.	M

69 Degrees.

21 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang.	Secant.	Co-sec.	M
0	9.554329	9.970152	9.584177	10.415823	10.029848	10.445671	60
1	9.554658	9.970103	9.584555	10.415445	10.029897	10.445342	59
2	9.554987	9.970055	9.584932	10.415068	10.029945	10.445013	58
3	9.555315	9.970006	9.585309	10.414691	10.029994	10.444685	57
4	9.555643	9.969957	9.585686	10.414314	10.030043	10.444357	56
5	9.555971	9.969909	9.586062	10.413938	10.030091	10.444029	55
6	9.556299	9.969860	9.586439	10.413561	10.030140	10.443701	54
7	9.556626	9.969811	9.586815	10.413185	10.030189	10.443374	53
8	9.556953	9.969762	9.587190	10.412810	10.030238	10.443047	52
9	9.557280	9.969714	9.587566	10.412434	10.030286	10.442720	51
10	9.557606	9.969665	9.587941	10.412059	10.030335	10.442394	50
11	9.557932	9.969616	9.588316	10.411684	10.030384	10.442068	49
12	9.558258	9.969567	9.588691	10.411309	10.030433	10.441742	48
13	9.558583	9.969518	9.589066	10.410934	10.030482	10.441417	47
14	9.558909	9.969469	9.589440	10.410560	10.030531	10.441091	46
15	9.559234	9.969420	9.589814	10.410186	10.030580	10.440766	45
16	9.559558	9.969370	9.590188	10.409812	10.030630	10.440442	44
17	9.559883	9.969321	9.590562	10.409438	10.030679	10.440117	43
18	9.560207	9.969272	9.590935	10.409065	10.030728	10.439793	42
19	9.560531	9.969223	9.591308	10.408692	10.030777	10.439469	41
20	9.560855	9.969173	9.591681	10.408319	10.030827	10.439145	40
21	9.561178	9.969124	9.592054	10.407946	10.030876	10.438822	39
22	9.561501	9.969075	9.592426	10.407574	10.030925	10.438499	38
23	9.561824	9.969025	9.592798	10.407202	10.030975	10.438176	37
24	9.562146	9.968976	9.593171	10.406829	10.031024	10.437854	36
25	9.562468	9.968926	9.593542	10.406458	10.031074	10.437532	35
26	9.562790	9.968877	9.593914	10.406086	10.031123	10.437210	34
27	9.563112	9.968827	9.594285	10.405715	10.031173	10.436888	33
28	9.563433	9.968777	9.594656	10.405344	10.031223	10.436567	32
29	9.563755	9.968728	9.595027	10.404973	10.031272	10.436245	31
30	9.564075	9.968678	9.595398	10.404602	10.031322	10.435925	30
31	9.564396	9.968628	9.595768	10.404232	10.031372	10.435604	29
32	9.564716	9.968578	9.596138	10.403862	10.031422	10.435284	28
33	9.565036	9.968528	9.596508	10.403492	10.031472	10.434964	27
34	9.565356	9.968479	9.596878	10.403122	10.031521	10.434644	26
35	9.565676	9.968429	9.597247	10.402753	10.031571	10.434324	25
36	9.565995	9.968379	9.597616	10.402384	10.031621	10.434005	24
37	9.566314	9.968329	9.597985	10.402015	10.031671	10.433686	23
38	9.566632	9.968278	9.598354	10.401646	10.031722	10.433368	22
39	9.566951	9.968228	9.598722	10.401278	10.031772	10.433049	21
40	9.567269	9.968178	9.599091	10.400909	10.031822	10.432731	20
41	9.567587	9.968128	9.599459	10.400541	10.031872	10.432413	19
42	9.567904	9.968078	9.599827	10.400173	10.031922	10.432096	18
43	9.568222	9.968027	9.600194	10.399806	10.031973	10.431778	17
44	9.568539	9.967977	9.600562	10.399438	10.032023	10.431461	16
45	9.568856	9.967927	9.600929	10.399071	10.032073	10.431144	15
46	9.569172	9.967876	9.601096	10.398704	10.032124	10.430828	14
47	9.569488	9.967826	9.601662	10.398338	10.032174	10.430512	13
48	9.569804	9.967775	9.602029	10.397971	10.032225	10.430196	12
49	9.570120	9.967725	9.602395	10.397605	10.032275	10.429880	11
50	9.570435	9.967674	9.602761	10.397239	10.032326	10.429565	10
51	9.570751	9.967624	9.603127	10.396873	10.032376	10.429249	9
52	9.571066	9.967573	9.603493	10.396507	10.032427	10.428934	8
53	9.571380	9.967522	9.603858	10.396142	10.032478	10.428620	7
54	9.571695	9.967471	9.604223	10.395777	10.032529	10.428305	6
55	9.572009	9.967421	9.604588	10.395412	10.032579	10.427991	5
56	9.572323	9.967370	9.604953	10.395047	10.032630	10.427677	4
57	9.572636	9.967319	9.605317	10.394683	10.032681	10.427364	3
58	9.572950	9.967268	9.605682	10.394318	10.032732	10.427050	2
59	9.573263	6.967217	9.606046	10.393954	10.032783	10.426737	1
60	9.573575	9.967166	9.606410	10.393590	10.032834	10.426425	0
M	Co sine.	Sine.	Co-tang	Tang.	Co-sec.	Secant	M

68 Degrees.

22 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang.	Secant.	Co-sec.	M
0	9.573575	9.967166	9.606410	10.393590	10.032834	10.426425	60
1	9.573888	9.967115	9.606773	10.393227	10.032885	10.426112	59
2	9.574200	9.967064	9.607137	10.392863	10.032936	10.425800	58
3	9.574512	9.967013	9.607500	10.392500	10.032987	10.425488	57
4	9.574824	9.966961	9.607863	10.392137	10.033039	10.425176	56
5	9.575136	9.966910	9.608225	10.391775	10.033090	10.424864	55
6	9.575447	9.966859	9.608588	10.391412	10.033141	10.424553	54
7	9.575758	9.966808	9.608950	10.391050	10.033192	10.424242	53
8	9.576069	9.966756	9.609312	10.390688	10.033244	10.423931	52
9	9.576379	9.966705	9.609674	10.390326	10.033295	10.423621	51
10	9.576689	9.966653	9.610036	10.389964	10.033347	10.423311	50
11	9.576999	9.966602	9.610397	10.389603	10.033398	10.423001	49
12	9.577309	9.966550	9.610759	10.389241	10.033450	10.422691	48
13	9.577618	9.966499	9.611120	10.388880	10.033501	10.422382	47
14	9.577927	9.966447	9.611480	10.388520	10.033553	10.422073	46
15	9.578236	9.966395	9.611841	10.388159	10.033605	10.421764	45
16	9.578545	9.966344	9.612201	10.387799	10.033656	10.421455	44
17	9.578853	9.966292	9.612561	10.387439	10.033708	10.421147	43
18	9.579162	9.966240	9.612921	10.387079	10.033760	10.420838	42
19	9.579470	9.966188	9.613281	10.386719	10.033812	10.420530	41
20	9.579777	9.966136	9.613641	10.386359	10.033864	10.420223	40
21	9.580085	9.966085	9.614000	10.386000	10.033915	10.419915	39
22	9.580392	9.966033	9.614359	10.385641	10.033967	10.419608	38
23	9.580699	9.965981	9.614718	10.385282	10.034019	10.419301	37
24	9.581005	9.965929	9.615077	10.384923	10.034071	10.418995	36
25	9.581312	9.965876	9.615435	10.384565	10.034124	10.418688	35
26	9.581618	9.965824	9.615793	10.384207	10.034176	10.418382	34
27	9.581924	9.965772	9.616151	10.383849	10.034228	10.418076	33
28	9.582229	9.965720	9.616509	10.383491	10.034280	10.417771	32
29	9.582535	9.965668	9.616867	10.383133	10.034332	10.417465	31
30	9.582840	9.965615	9.617224	10.382776	10.034385	10.417160	30
31	9.583145	9.965563	9.617582	10.382418	10.034437	10.416855	29
32	9.583449	9.965511	9.617939	10.382061	10.034489	10.416551	28
33	9.583754	9.965458	9.618295	10.381705	10.034542	10.416246	27
34	9.584058	9.965406	9.618652	10.381348	10.034594	10.415942	26
35	9.584361	9.965353	9.619008	10.380992	10.034647	10.415639	25
36	9.584665	9.965301	9.619364	10.380636	10.034699	10.415335	24
37	9.584968	9.965248	9.619721	10.380279	10.034752	10.415032	23
38	9.585272	9.965195	9.620076	10.379924	10.034805	10.414728	22
39	9.585574	9.965143	9.620432	10.379568	10.034857	10.414426	21
40	9.585877	9.965090	9.620787	10.379213	10.034910	10.414123	20
41	9.586179	9.965037	9.621142	10.378858	10.034963	10.413821	19
42	9.586482	9.964984	9.621497	10.378503	10.035016	10.413518	18
43	9.586783	9.964931	9.621852	10.378148	10.035069	10.413217	17
44	9.587085	9.964879	9.622207	10.377793	10.035121	10.412915	16
45	9.587386	9.964826	9.622561	10.377439	10.035174	10.412614	15
46	9.587688	9.964773	9.622915	10.377085	10.035227	10.412312	14
47	9.587989	9.964720	9.623269	10.376731	10.035280	10.412011	13
48	9.588289	9.964666	9.623623	10.376377	10.035334	10.411711	12
49	9.588590	9.964613	9.623976	10.376024	10.035387	10.411410	11
50	9.588890	9.964560	9.624330	10.375670	10.035440	10.411110	10
51	9.589190	9.964507	9.624683	10.375317	10.035493	10.410810	9
52	9.589489	9.964454	9.625036	10.374964	10.035546	10.410511	8
53	9.589789	9.964400	9.625388	10.374612	10.035600	10.410211	7
54	9.590088	9.964347	9.625741	10.374259	10.035653	10.409912	6
55	9.590387	9.964294	9.626093	10.373907	10.035706	10.409613	5
56	9.590686	9.964240	9.626445	10.373555	10.035760	10.409314	4
57	9.590984	9.964187	9.626797	10.373203	10.035813	10.409016	3
58	9.591282	9.964133	9.627149	10.372851	10.035867	10.408718	2
59	9.591580	9.964080	9.627501	10.372499	10.035920	10.408420	1
60	9.591878	9.964026	9.627852	10.372148	10.035974	10.408122	0
M	Co-sine.	Sine.	Co-tang.	Tang.	Co-sec.	Secant.	M

67 Degrees.

23 Degrees.

M	Sine	Co-sine.	Tang	Co-tang.	Secant.	Co-sec.	M
0	9.591878	9.964026	9.627852	10.372148	10.035974	10.408122	60
1	9.592176	9.963972	9.628203	10.371797	10.036028	10.407824	59
2	9.592473	9.963919	9.628554	10.371446	10.036081	10.407527	58
3	9.592770	9.963865	9.628905	10.371095	10.036135	10.407230	57
4	9.593067	9.963811	9.629255	10.370745	10.036189	10.406933	56
5	9.593363	9.963757	9.629606	10.370394	10.036243	10.406637	55
6	9.593659	9.963704	9.629956	10.370044	10.036296	10.406341	54
7	9.593955	9.963650	9.630306	10.369694	10.036350	10.406045	53
8	9.594251	9.963596	9.630656	10.369344	10.036404	10.405749	52
9	9.594547	9.963542	9.631005	10.368995	10.036458	10.405453	51
10	9.594842	9.963488	9.631355	10.368645	10.036512	10.405158	50
11	9.595137	9.963434	9.631704	10.368296	10.036566	10.404863	49
12	9.595432	9.963379	9.632053	10.367947	10.036621	10.404568	48
13	9.595727	9.963325	9.632401	10.367599	10.036675	10.404273	47
14	9.596021	9.963271	9.632750	10.367250	10.036729	10.403979	46
15	9.596315	9.963217	9.633098	10.366902	10.036783	10.403685	45
16	9.596609	9.963163	9.633447	10.366553	10.036837	10.403391	44
17	9.596903	9.963108	9.633795	10.366205	10.036892	10.403097	43
18	9.597196	9.963054	9.634143	10.365857	10.036946	10.402804	42
19	9.597490	9.962999	9.634490	10.365510	10.037001	10.402510	41
20	9.597783	9.962945	9.634838	10.365162	10.037055	10.402217	40
21	9.598075	9.962890	9.635185	10.364815	10.037110	10.401925	39
22	9.598368	9.962836	9.635532	10.364468	10.037164	10.401632	38
23	9.598660	9.962781	9.635879	10.364121	10.037219	10.401340	37
24	9.598952	9.962727	9.636226	10.363774	10.037273	10.401048	36
25	9.599244	9.962672	9.636572	10.363428	10.037328	10.400756	35
26	9.599536	9.962617	9.636919	10.363081	10.037383	10.400464	34
27	9.599827	9.962562	9.637265	10.362735	10.037438	10.400173	33
28	9.600118	9.962508	9.637611	10.362389	10.037492	10.399882	32
29	9.600409	9.962453	9.637956	10.362044	10.037547	10.399591	31
30	9.600700	9.962398	9.638302	10.361698	10.037602	10.399300	30
31	9.600990	9.962343	9.638647	10.361353	10.037657	10.399010	29
32	9.601280	9.962288	9.638992	10.361008	10.037712	10.398720	28
33	9.601570	9.962233	9.639337	10.360663	10.037767	10.398430	27
34	9.601860	9.962178	9.639682	10.360318	10.037822	10.398140	26
35	9.602150	9.962123	9.640027	10.359973	10.037877	10.397850	25
36	9.602439	9.962067	9.640371	10.359629	10.037933	10.397561	24
37	9.602728	9.962012	9.640716	10.359284	10.037988	10.397272	23
38	9.603017	9.961957	9.641060	10.358940	10.038043	10.396983	22
39	9.603305	9.961902	9.641404	10.358596	10.038098	10.396695	21
40	9.603594	9.961846	9.641747	10.358253	10.038154	10.396406	20
41	9.603882	9.961791	9.642091	10.357909	10.038209	10.396118	19
42	9.604170	9.961735	9.642434	10.357566	10.038265	10.395830	18
43	9.604457	9.961680	9.642777	10.357223	10.038320	10.395543	17
44	9.604745	9.961624	9.643120	10.356880	10.038376	10.395255	16
45	9.605032	9.961569	9.643463	10.356537	10.038431	10.394968	15
46	9.605319	9.961513	9.643806	10.356194	10.038487	10.394681	14
47	9.605606	9.961458	9.644148	10.355852	10.038542	10.394394	13
48	9.605892	9.961402	9.644490	10.355510	10.038598	10.394108	12
49	9.606179	9.961346	9.644832	10.355168	10.038654	10.393821	11
50	9.606465	9.961290	9.645174	10.354826	10.038710	10.393535	10
51	9.606751	9.961235	9.645516	10.354484	10.038765	10.393249	9
52	9.607036	9.961179	9.645857	10.354143	10.038821	10.392964	8
53	9.607322	9.961123	9.646199	10.353801	10.038877	10.392678	7
54	9.607607	9.961067	9.646540	10.353460	10.038933	10.392393	6
55	9.607892	9.961011	9.646881	10.353119	10.038989	10.392108	5
56	9.608177	9.960955	9.647222	10.352778	10.039045	10.391823	4
57	9.608461	9.960899	9.647562	10.352438	10.039101	10.391539	3
58	9.608745	9.960843	9.647903	10.352097	10.039157	10.391255	2
59	9.609029	9.960786	9.648243	10.351757	10.039214	10.390971	1
60	9.609313	9.960730	9.648583	10.351417	10.039270	10.390687	0
M	Co-sine.	Sine.	Co-tang	Tang.	Co-sec.	Secant.	M

66 Degrees.

24 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang.	Secant.	Co-sec.	M
0	9.609313	9.960730	9.648583	10.351417	10.039270	10.390687	60
1	9.609597	9.960674	9.648923	10.351077	10.039326	10.390403	59
2	9.609880	9.960618	9.649263	10.350737	10.039382	10.390120	58
3	9.610164	9.960561	9.649602	10.350398	10.039439	10.389836	57
4	9.610447	9.960505	9.649942	10.350058	10.039495	10.389553	56
5	9.610729	9.960448	9.650281	10.349719	10.039552	10.389271	55
6	9.611012	9.960392	9.650620	10.349380	10.039608	10.388988	54
7	9.611294	9.960335	9.650959	10.349041	10.039665	10.388706	53
8	9.611576	9.960279	9.651297	10.348703	10.039721	10.388424	52
9	9.611858	9.960222	9.651636	10.348364	10.039778	10.388142	51
10	9.612140	9.960165	9.651974	10.348026	10.039835	10.387860	50
11	9.612421	9.960109	9.652312	10.347688	10.039891	10.387579	49
12	9.612702	9.960052	9.652650	10.347350	10.039948	10.387298	48
13	9.612983	9.959995	9.652988	10.347012	10.040005	10.387017	47
14	9.613264	9.959938	9.653326	10.346674	10.040062	10.386736	46
15	9.613545	9.959882	9.653663	10.346337	10.040118	10.386455	45
16	9.613825	9.959825	9.654000	10.346000	10.040175	10.386175	44
17	9.614105	9.959768	9.654337	10.345663	10.040232	10.385895	43
18	9.614385	9.959711	9.654674	10.345326	10.040289	10.385615	42
19	9.614665	9.959654	9.655011	10.344989	10.040346	10.385335	41
20	9.614944	9.959596	9.655348	10.344652	10.040404	10.385056	40
21	9.615223	9.959539	9.655684	10.344316	10.040461	10.384777	39
22	9.615502	9.959482	9.656020	10.343980	10.040518	10.384498	38
23	9.615781	9.959425	9.656356	10.343644	10.040575	10.384219	37
24	9.616060	9.959368	9.656692	10.343308	10.040632	10.383940	36
25	9.616338	9.959310	9.657028	10.342972	10.040690	10.383662	35
26	9.616616	9.959253	9.657364	10.342636	10.040747	10.383384	34
27	9.616894	9.959195	9.657699	10.342301	10.040805	10.383106	33
28	9.617172	9.959138	9.658034	10.341966	10.040862	10.382828	32
29	9.617450	9.959080	9.658369	10.341631	10.040919	10.382550	31
30	9.617727	9.959023	9.658704	10.341296	10.040977	10.382273	30
31	9.618004	9.958965	9.659039	10.340961	10.041035	10.381996	29
32	9.618281	9.958908	9.659373	10.340627	10.041092	10.381719	28
33	9.618558	9.958850	9.659708	10.340292	10.041150	10.381442	27
34	9.618834	9.958792	9.660042	10.339958	10.041208	10.381166	26
35	9.619110	9.958734	9.660376	10.339624	10.041266	10.380890	25
36	9.619386	9.958677	9.660710	10.339290	10.041323	10.380614	24
37	9.619662	9.958619	9.661043	10.338957	10.041381	10.380338	23
38	9.619938	9.958561	9.661377	10.338623	10.041439	10.380062	22
39	9.620213	9.958503	9.661710	10.338290	10.041497	10.379787	21
40	9.620488	9.958445	9.662043	10.337957	10.041555	10.379512	20
41	9.620763	9.958387	9.662376	10.337624	10.041613	10.379237	19
42	9.621038	9.958329	9.662709	10.337291	10.041671	10.378962	18
43	9.621313	9.958271	9.663042	10.336958	10.041729	10.378687	17
44	9.621587	9.958213	9.663375	10.336625	10.041787	10.378413	16
45	9.621861	9.958154	9.663707	10.336293	10.041846	10.378139	15
46	9.622135	9.958096	9.664039	10.335961	10.041904	10.377865	14
47	9.622409	9.958038	9.664371	10.335629	10.041962	10.377591	13
48	9.622682	9.957979	9.664703	10.335297	10.042021	10.377318	12
49	9.622956	9.957921	9.665035	10.334965	10.042079	10.377044	11
50	9.623229	9.957863	9.665366	10.334634	10.042137	10.376771	10
51	9.623502	9.957804	9.665697	10.334303	10.042196	10.376498	9
52	9.623774	9.957746	9.666029	10.333971	10.042254	10.376226	8
53	9.624047	9.957687	9.666360	10.333640	10.042313	10.375953	7
54	9.624319	9.957628	9.666691	10.333309	10.042372	10.375681	6
55	9.624591	9.957570	9.667021	10.332979	10.042430	10.375409	5
56	9.624863	9.957511	9.667352	10.332648	10.042489	10.375137	4
57	9.625135	9.957452	9.667682	10.332318	10.042548	10.374865	3
58	9.625406	9.957393	9.668013	10.331987	10.042607	10.374594	2
59	9.625677	9.957335	9.668343	10.331657	10.042665	10.374323	1
60	9.625948	9.957276	9.668672	10.331328	10.042724	10.374052	0
M	Co-sine.	Sine.	Co-tang.	Tang.	Co-sec.	Secant.	M

65 Degrees.

25 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang.	Secant.	Co-sec.	M
0	9.625948	9.957276	9.668673	10.331327	10.042724	10.374052	60
1	9.626219	9.957217	9.669002	10.330998	10.042783	10.373781	59
2	9.626490	9.957158	9.669332	10.330668	10.042842	10.373510	58
3	9.626760	9.957099	9.669661	10.330339	10.042901	10.373240	57
4	9.627030	9.957040	9.669991	10.330009	10.042960	10.372970	56
5	9.627300	9.956981	9.670320	10.329680	10.043019	10.372700	55
6	9.627570	9.956921	9.670649	10.329351	10.043079	10.372430	54
7	9.627840	9.956862	9.670977	10.329023	10.043138	10.372160	53
8	9.628109	9.956803	9.671306	10.328694	10.043197	10.371891	52
9	9.628378	9.956744	9.671634	10.328366	10.043256	10.371622	51
10	9.628647	9.956684	9.671963	10.328037	10.043316	10.371353	50
11	9.628916	9.956625	9.672291	10.327709	10.043375	10.371084	49
12	9.629185	9.956566	9.672619	10.327381	10.043434	10.370815	48
13	9.629453	9.956506	9.672947	10.327053	10.043494	10.370547	47
14	9.629721	9.956447	9.673274	10.326726	10.043553	10.370279	46
15	9.629989	9.956387	9.673602	10.326398	10.043613	10.370011	45
16	9.630257	9.956327	9.673929	10.326071	10.043673	10.369743	44
17	9.630524	9.956268	9.674257	10.325743	10.043732	10.369476	43
18	9.630792	9.956208	9.674584	10.325416	10.043792	10.369208	42
19	9.631059	9.956148	9.674910	10.325090	10.043852	10.368941	41
20	9.631326	9.956089	9.675237	10.324763	10.043911	10.368674	40
21	9.631593	9.956029	9.675564	10.324436	10.043971	10.368407	39
22	9.631859	9.955969	9.675890	10.324110	10.044031	10.368141	38
23	9.632125	9.955909	9.676217	10.323783	10.044091	10.367875	37
24	9.632392	9.955849	9.676543	10.323457	10.044151	10.367608	36
25	9.632658	9.955789	9.676869	10.323131	10.044211	10.367342	35
26	9.632923	9.955729	9.677194	10.322806	10.044271	10.367077	34
27	9.633189	9.955669	9.677520	10.322480	10.044331	10.366811	33
28	9.633454	9.955609	9.677846	10.322154	10.044391	10.366546	32
29	9.633719	9.955548	9.678171	10.321829	10.044452	10.366281	31
30	9.633984	9.955488	9.678496	10.321504	10.044512	10.366016	30
31	9.634249	9.955428	9.678821	10.321179	10.044572	10.365751	29
32	9.634514	9.955368	9.679146	10.320854	10.044632	10.365486	28
33	9.634778	9.955307	9.679471	10.320529	10.044693	10.365222	27
34	9.635042	9.955247	9.679795	10.320205	10.044753	10.364958	26
35	9.635306	9.955186	9.680120	10.319880	10.044814	10.364694	25
36	9.635570	9.955126	9.680444	10.319556	10.044874	10.364430	24
37	9.635834	9.955065	9.680768	10.319232	10.044935	10.364166	23
38	9.636097	9.955005	9.681092	10.318908	10.044995	10.363903	22
39	9.636360	9.954944	9.681416	10.318584	10.045056	10.363640	21
40	9.636623	9.954883	9.681740	10.318260	10.045117	10.363377	20
41	9.636886	9.954823	9.682063	10.317937	10.045177	10.363114	19
42	9.637148	9.954762	9.682387	10.317613	10.045238	10.362852	18
43	9.637411	9.954701	9.682710	10.317290	10.045299	10.362589	17
44	9.637673	9.954640	9.683033	10.316967	10.045360	10.362327	16
55	9.637935	9.954579	9.683356	10.316644	10.045421	10.362065	15
46	9.638197	9.954518	9.683679	10.316321	10.045482	10.361803	14
47	9.638458	9.954457	9.684001	10.315999	10.045543	10.361542	13
48	9.638720	9.954396	9.684324	10.315676	10.045604	10.361280	12
49	9.638981	9.954335	9.684646	10.315354	10.045665	10.361019	11
50	9.639242	9.954274	9.684968	10.315032	10.045726	10.360758	10
51	9.639503	9.954213	9.685290	10.314710	10.045787	10.360497	9
52	9.639764	9.954152	9.685612	10.314388	10.045848	10.360236	8
53	9.640024	9.954090	9.685934	10.314066	10.045910	10.359976	7
54	9.640284	9.954029	9.686255	10.313745	10.045971	10.359716	6
55	9.640544	9.953968	9.686577	10.313423	10.046032	10.359456	5
56	9.640804	9.953906	9.686898	10.313102	10.046094	10.359196	4
57	9.641064	9.953845	9.687219	10.312781	10.046155	10.358936	3
58	9.641324	9.953783	9.687540	10.312460	10.046217	10.358676	2
59	9.641583	9.953722	9.687861	10.312139	10.046278	10.358417	1
60	9.641842	9.953660	9.688182	10.311818	10.046340	10.358158	0
M	Co-sine.	Sine.	Co-tang	Tang.	Co-sec	Secant.	M

64 Degrees.

26 Degrees.

M	Sine.	Co-sine.	Tang	Co-tang	Secant.	Co-sec.	M
0	9.641842	9.953660	9.688182	10.311818	10.046340	10.358158	60
1	9.642101	9.953599	9.688502	10.311498	10.046401	10.357899	59
2	9.642360	9.953537	9.688823	10.311177	10.046463	10.357640	58
3	9.642618	9.953475	9.689143	10.310857	10.046525	10.357382	57
4	9.642877	9.953413	9.689463	10.310537	10.046587	10.357123	56
5	9.643135	9.953352	9.689783	10.310217	10.046648	10.356865	55
6	9.643393	9.953290	9.690103	10.309897	10.046710	10.356607	54
7	9.643650	9.953228	9.690423	10.309577	10.046772	10.356350	53
8	9.643908	9.953166	9.690742	10.309258	10.046834	10.356092	52
9	9.644165	9.953104	9.691062	10.308938	10.046896	10.355835	51
10	9.644423	9.953042	9.691381	10.308619	10.046958	10.355577	50
11	9.644680	9.952980	9.691700	10.308300	10.047020	10.355320	49
12	9.644936	9.952918	9.692019	10.307981	10.047082	10.355064	48
13	9.645193	9.952855	9.692338	10.307662	10.047145	10.354807	47
14	9.645450	9.952793	9.692656	10.307344	10.047207	10.354550	46
15	9.645706	9.952731	9.692975	10.307025	10.047269	10.354294	45
16	9.645962	9.952669	9.693293	10.306707	10.047331	10.354038	44
17	9.646218	9.952606	9.693612	10.306388	10.047394	10.353782	43
18	9.646474	9.952544	9.693930	10.306070	10.047456	10.353526	42
19	9.646729	9.952481	9.694248	10.305752	10.047519	10.353271	41
20	9.646984	9.952419	9.694566	10.305434	10.047581	10.353016	40
21	9.647240	9.952356	9.694883	10.305117	10.047644	10.352760	39
22	9.647494	9.952294	9.695201	10.304799	10.047706	10.352506	38
23	9.647749	9.952231	9.695518	10.304482	10.047769	10.352251	37
24	9.648004	9.952168	9.695836	10.304164	10.047832	10.351996	36
25	9.648258	9.952106	9.696153	10.303847	10.047894	10.351742	35
26	9.648512	9.952043	9.696470	10.303530	10.047957	10.351488	34
27	9.648766	9.951980	9.696787	10.303213	10.048020	10.351234	33
28	9.649020	9.951917	9.697103	10.302897	10.048083	10.350980	32
29	9.649274	9.951854	9.697420	10.302580	10.048146	10.350726	31
30	9.649527	9.951791	9.697736	10.302264	10.048209	10.350473	30
31	9.649781	9.951728	9.698053	10.301947	10.048272	10.350219	29
32	9.650034	9.951665	9.698369	10.301631	10.048335	10.349966	28
33	9.650287	9.951602	9.698685	10.301315	10.048398	10.349713	27
34	9.650539	9.951539	9.699001	10.300999	10.048461	10.349461	26
35	9.650792	9.951476	9.699316	10.300684	10.048524	10.349208	25
36	9.651044	9.951412	9.699632	10.300368	10.048588	10.348956	24
37	9.651297	9.951349	9.699947	10.300053	10.048651	10.348703	23
38	9.651549	9.951286	9.700263	10.299737	10.048714	10.348451	22
39	9.651800	9.951222	9.700578	10.299422	10.048778	10.348200	21
40	9.652052	9.951159	9.700893	10.299107	10.048841	10.347948	20
41	9.652304	9.951096	9.701208	10.298792	10.048904	10.347696	19
42	9.652555	9.951032	9.701523	10.298477	10.048968	10.347445	18
43	9.652806	9.950968	9.701837	10.298163	10.049032	10.347194	17
44	9.653057	9.950905	9.702152	10.297848	10.049095	10.346943	16
45	9.653308	9.950841	9.702466	10.297534	10.049159	10.346692	15
46	9.653558	9.950778	9.702780	10.297220	10.049222	10.346442	14
47	9.653808	9.950714	9.703095	10.296905	10.049286	10.346192	13
48	9.654059	9.950650	9.703409	10.296591	10.049350	10.345941	12
49	9.654309	9.950586	9.703723	10.296277	10.049414	10.345691	11
50	9.654558	9.950522	9.704036	10.295964	10.049478	10.345442	10
51	9.654808	9.950458	9.704350	10.295650	10.049542	10.345192	9
52	9.655058	9.950394	9.704663	10.295337	10.049606	10.344942	8
53	9.655307	9.950330	9.704977	10.295023	10.049670	10.344693	7
54	9.655556	9.950266	9.705290	10.294710	10.049734	10.344444	6
55	9.655805	9.950202	9.705603	10.294397	10.049798	10.344195	5
56	9.656054	9.950138	9.705916	10.294084	10.049862	10.343946	4
57	9.656302	9.950074	9.706228	10.293772	10.049926	10.343698	3
58	9.656551	9.950010	9.706541	10.293459	10.049990	10.343449	2
59	9.656799	9.949945	9.706854	10.293146	10.050055	10.343201	1
60	9.657047	9.949881	9.707166	10.292834	10.050119	10.342953	0
M	Co-sine.	Sine.	Co-tang.	Tang.	Co-sec.	Secant.	M

63 Degrees.

27 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang	Secant.	Co-sec.	M
0	9.657047	9.949881	9.707166	10.292834	10.050119	10.342953	60
1	9.657295	9.949816	9.707478	10.292522	10.050184	10.342705	59
2	9.657542	9.949752	9.707790	10.292210	10.050248	10.342458	58
3	9.657790	9.949688	9.708102	10.291898	10.050312	10.342210	57
4	9.658037	9.949623	9.708414	10.291586	10.050377	10.341963	56
5	9.658284	9.949558	9.708726	10.291274	10.050442	10.341716	55
6	9.658531	9.949494	9.709037	10.290963	10.050506	10.341469	54
7	9.658778	9.949429	9.709349	10.290651	10.050571	10.341222	53
8	9.659025	9.949364	9.709660	10.290340	10.050636	10.340975	52
9	9.659271	9.949300	9.709971	10.290029	10.050700	10.340729	51
10	9.659517	9.949235	9.710282	10.289718	10.050765	10.340483	50
11	9.659763	9.949170	9.710593	10.289407	10.050830	10.340237	49
12	9.660009	9.949105	9.710904	10.289096	10.050895	10.339991	48
13	9.660255	9.949040	9.711215	10.288785	10.050960	10.339745	47
14	9.660501	9.948975	9.711525	10.288475	10.051025	10.339499	46
15	9.660746	9.948910	9.711836	10.288164	10.051090	10.339254	45
16	9.660991	9.948845	9.712146	10.287854	10.051155	10.339009	44
17	9.661236	9.948780	9.712456	10.287544	10.051220	10.338764	43
18	9.661481	9.948715	9.712766	10.287234	10.051285	10.338519	42
19	9.661726	9.948650	9.713076	10.286924	10.051350	10.338274	41
20	9.661970	9.948584	9.713386	10.286614	10.051416	10.338030	40
21	9.662214	9.948519	9.713696	10.286304	10.051481	10.337786	39
22	9.662459	9.948454	9.714005	10.285995	10.051546	10.337541	38
23	9.662703	9.948388	9.714314	10.285686	10.051612	10.337297	37
24	9.662946	9.948323	9.714624	10.285376	10.051677	10.337054	36
25	9.663190	9.948257	9.714933	10.285067	10.051743	10.336810	35
26	9.663433	9.948192	9.715242	10.284758	10.051808	10.336567	34
27	9.663677	9.948126	9.715551	10.284449	10.051874	10.336323	33
28	9.663920	9.948060	9.715860	10.284140	10.051940	10.336080	32
29	9.664163	9.947995	9.716168	10.283832	10.052005	10.335837	31
30	9.664406	9.947929	9.716477	10.283523	10.052071	10.335594	30
31	9.664648	9.947863	9.716785	10.283215	10.052137	10.335352	29
32	9.664891	9.947797	9.717093	10.282907	10.052203	10.335109	28
33	9.665133	9.947731	9.717401	10.282599	10.052269	10.334867	27
34	9.665375	9.947665	9.717709	10.282291	10.052335	10.334625	26
35	9.665617	9.947600	9.718017	10.281983	10.052400	10.334383	25
36	9.665859	9.947533	9.718325	10.281675	10.052467	10.334141	24
37	9.666100	9.947467	9.718633	10.281367	10.052533	10.333900	23
38	9.666342	9.947401	9.718940	10.281060	10.052599	10.333658	22
39	9.666583	9.947335	9.719248	10.280752	10.052665	10.333417	21
40	9.666824	9.947269	9.719555	10.280445	10.052731	10.333176	20
41	9.667065	9.947203	9.719862	10.280138	10.052797	10.332935	19
42	9.667305	9.947136	9.720169	10.279831	10.052864	10.332695	18
43	9.667546	9.947070	9.720476	10.279524	10.052930	10.332454	17
44	9.667786	9.947004	9.720783	10.279217	10.052996	10.332214	16
45	9.668027	9.946937	9.721089	10.278911	10.053063	10.331973	15
46	9.668267	9.946871	9.721396	10.278604	10.053129	10.331733	14
47	9.668506	9.946804	9.721702	10.278298	10.053196	10.331494	13
48	9.668746	9.946738	9.722009	10.277991	10.053262	10.331254	12
49	9.668986	9.946671	9.722315	10.277685	10.053329	10.331014	11
50	9.669225	9.946604	9.722621	10.277379	10.053396	10.330775	10
51	9.669464	9.946538	9.722927	10.277073	10.053462	10.330536	9
52	9.669703	9.946471	9.723232	10.276768	10.053529	10.330297	8
53	9.669942	9.946404	9.723538	10.276462	10.053596	10.330058	7
54	9.670181	9.946337	9.723844	10.276156	10.053663	10.329819	6
55	9.670419	9.946270	9.724149	10.275851	10.053730	10.329581	5
56	9.670658	9.946203	9.724454	10.275546	10.053797	10.329342	4
57	9.670896	9.946136	9.724759	10.275241	10.053864	10.329104	3
58	9.671134	9.946069	9.725065	10.274935	10.053931	10.328866	2
59	9.671372	9.946002	9.725369	10.274631	10.053998	10.328628	1
60	9.671609	9.945935	9.725674	10.274326	10.054065	10.328391	0
M	Co-sine.	Sine.	Co-tang.	Tang.	Co-sec.	Secant.	M

62 Degrees.

28 Degrees.

M	Sine.	Co-sine	Tang.	Co-tang.	Secant.	Co-sec	M
0	9.671609	9.945935	9.725674	10.274326	10.054065	10.328391	60
1	9.671847	9.945868	9.725979	10.274021	10.054132	10.328153	59
2	9.672084	9.945800	9.726284	10.273716	10.054200	10.327916	58
3	9.672321	9.945733	9.726588	10.273412	10.054267	10.327679	57
4	9.672558	9.945666	9.726892	10.273108	10.054334	10.327442	56
5	9.672795	9.945598	9.727197	10.272803	10.054402	10.327205	55
6	9.673032	9.945531	9.727501	10.272499	10.054469	10.326968	54
7	9.673268	9.945464	9.727805	10.272195	10.054536	10.326732	53
8	9.673505	9.945396	9.728109	10.271891	10.054604	10.326495	52
9	9.673741	9.945328	9.728412	10.271588	10.054672	10.326259	51
10	9.673977	9.945261	9.728716	10.271284	10.054739	10.326023	50
11	9.674213	9.945193	9.729020	10.270980	10.054807	10.325787	49
12	9.674448	9.945125	9.729323	10.270677	10.054875	10.325552	48
13	9.674684	9.945058	9.729626	10.270374	10.054942	10.325316	47
14	9.674919	9.944990	9.729929	10.270071	10.055010	10.325081	46
15	9.675155	9.944922	9.730233	10.269767	10.055078	10.324845	45
16	9.675390	9.944854	9.730535	10.269465	10.055146	10.324610	44
17	9.675624	9.944786	9.730838	10.269162	10.055214	10.324376	43
18	9.675859	9.944718	9.731141	10.268859	10.055282	10.324141	42
19	9.676094	9.944650	9.731444	10.268556	10.055350	10.323906	41
20	9.676328	9.944582	9.731746	10.268254	10.055418	10.323672	40
21	9.676562	9.944514	9.732048	10.267952	10.055486	10.323438	39
22	9.676796	9.944446	9.732351	10.267649	10.055554	10.323204	38
23	9.677030	9.944377	9.732653	10.267347	10.055623	10.322970	37
24	9.677264	9.944309	9.732955	10.267045	10.055691	10.322736	36
25	9.677498	9.944241	9.733257	10.266743	10.055759	10.322502	35
26	9.677731	9.944172	9.733558	10.266442	10.055828	10.322269	34
27	9.677964	9.944104	9.733860	10.266140	10.055896	10.322036	33
28	9.678197	9.944036	9.734162	10.265838	10.055964	10.321803	32
29	9.678430	9.943967	9.734463	10.265537	10.056033	10.321570	31
30	9.678663	9.943899	9.734764	10.265236	10.056101	10.321337	30
31	9.678895	9.943830	9.735066	10.264934	10.056170	10.321105	29
32	9.679128	9.943761	9.735367	10.264633	10.056239	10.320872	28
33	9.679360	9.943693	9.735668	10.264332	10.056307	10.320640	27
34	9.679592	9.943624	9.735969	10.264031	10.056376	10.320408	26
35	9.679824	9.943555	9.736269	10.263731	10.056445	10.320176	25
36	9.680056	9.943486	9.736570	10.263430	10.056514	10.319944	24
37	9.680288	9.943417	9.736871	10.263129	10.056583	10.319712	23
38	9.680519	9.943348	9.737171	10.262829	10.056652	10.319481	22
39	9.680750	9.943279	9.737471	10.262529	10.056721	10.319250	21
40	9.680982	9.943210	9.737771	10.262229	10.056790	10.319018	20
41	9.681213	9.943141	9.738071	10.261929	10.056859	10.318787	19
42	9.681443	9.943072	9.738371	10.261629	10.056928	10.318557	18
43	9.681674	9.943003	9.738671	10.261329	10.056997	10.318326	17
44	9.681905	9.942934	9.738971	10.261029	10.057066	10.318095	16
45	9.682135	9.942864	9.739271	10.260729	10.057136	10.317865	15
46	9.682365	9.942795	9.739570	10.260430	10.057205	10.317635	14
47	9.682595	9.942726	9.739870	10.260130	10.057274	10.317405	13
48	9.682825	9.942656	9.740169	10.259831	10.057344	10.317175	12
49	9.683055	9.942587	9.740468	10.259532	10.057413	10.316945	11
50	9.683284	9.942517	9.740767	10.259233	10.057483	10.316716	10
51	9.683514	9.942448	9.741066	10.258934	10.057552	10.316486	9
52	9.683743	9.942378	9.741365	10.258635	10.057622	10.316257	8
53	9.683972	9.942308	9.741664	10.258336	10.057692	10.316028	7
54	9.684201	9.942239	9.741962	10.258038	10.057761	10.315799	6
55	9.684430	9.942169	9.742261	10.257739	10.057831	10.315570	5
56	9.684658	9.942099	9.742559	10.257441	10.057901	10.315342	4
57	9.684887	9.942029	9.742858	10.257142	10.057971	10.315113	3
58	9.685115	9.941959	9.743156	10.256844	10.058041	10.314885	2
59	9.685343	9.941889	9.743454	10.256546	10.058111	10.314657	1
60	9.685571	9.941819	9.743752	10.256248	10.058181	10.314429	0
M	Co-sine.	Sine.	Co-tang.	Tang.	Co-sec.	Secant.	M

61 Degrees.

29 Degrees.

M	Sine.	Co-sine.	Tang	Co-tang	Secant.	Co-sec.	M
0	9.685571	9.941819	9.743752	10.256248	10.058181	10.314429	60
1	9.685799	9.941749	9.744050	10.255950	10.058251	10.314201	59
2	9.686027	9.941679	9.744348	10.255652	10.058321	10.313973	58
3	9.686254	9.941609	9.744645	10.255355	10.058391	10.313746	57
4	9.686482	9.941539	9.744943	10.255057	10.058461	10.313518	56
5	9.686709	9.941469	9.745240	10.254760	10.058531	10.313291	55
6	9.686936	9.941398	9.745538	10.254462	10.058602	10.313064	54
7	9.687163	9.941328	9.745835	10.254165	10.058672	10.312837	53
8	9.687389	9.941258	9.746132	10.253868	10.058742	10.312611	52
9	9.687616	9.941187	9.746429	10.253571	10.058813	10.312384	51
10	9.687843	9.941117	9.746726	10.253274	10.058883	10.312157	50
11	9.688069	9.941046	9.747023	10.252977	10.058954	10.311931	49
12	9.688295	9.940975	3.747319	10.252681	10.059025	10.311705	48
13	9.688521	9.940905	9.747616	10.252384	10.059095	10.311479	47
14	9.688747	9.940834	9.747913	10.252087	10.059166	10.311253	46
15	9.688972	9.940763	9.748209	10.251791	10.059237	10.311028	45
16	9.689198	9.940693	9.748505	10.251495	10.059307	10.310802	44
17	9.689423	9.940622	9.748801	10.251199	10.059378	10.310577	43
18	9.689648	9.940551	9.749097	10.250903	10.059449	10.310352	42
19	9.689873	9.940480	9.749393	10.250607	10.059520	10.310127	41
20	9.690098	9.940409	9.749689	10.250311	10.059591	10.309902	40
21	9.690323	9.940338	9.749985	10.250015	10.059662	10.309677	39
22	9.690548	9.940267	9.750281	10.249719	10.059733	10.309452	38
23	9.690772	9.940196	9.750576	10.249424	10.059804	10.309228	37
24	9.690996	9.940125	9.750872	10.249128	10.059875	10.309004	36
25	9.691220	9.940054	9.751167	10.248833	10.059946	10.308780	35
26	9.691444	9.939982	9.751462	10.248538	10.060018	10.308556	34
27	9.691668	9.939911	9.751757	10.248243	10.060089	10.308332	33
28	9.691892	9.939840	9.752052	10.247948	10.060160	10.308108	32
29	9.692115	9.939768	9.752347	10.247653	10.060232	10.307885	31
30	9.692339	9.939697	9.752642	10.247358	10.060303	10.307661	30
31	9.692562	9.939625	9.752937	10.247063	10.060375	10.307438	29
32	9.692785	9.939554	9.753231	10.246769	10.060446	10.307215	28
33	9.693008	9.939482	9.753526	10.246474	10.060518	10.306992	27
34	9.693231	9.939410	9.753820	10.246180	10.060590	10.306769	26
35	9.693453	9.939339	9.754115	10.245885	10.060661	10.306547	25
36	9.693676	9.939267	9.754409	10.245591	10.060733	10.306324	24
37	9.693898	9.939195	9.754703	10.245297	10.060805	10.306102	23
38	9.694120	9.939123	9.754997	10.245003	10.060877	10.305880	22
39	9.694342	9.939052	9.755291	10.244709	10.060948	10.305658	21
40	9.694564	9.938980	9.755585	10.244415	10.061020	10.305436	20
41	9.694786	9.938908	9.755878	10.244122	10.061092	10.305214	19
42	9.695007	9.938836	9.756172	10.243828	10.061164	10.304993	18
43	9.695229	9.938763	9.756465	10.243535	10.061237	10.304771	17
44	9.695450	9.938691	9.756759	10.243241	10.061309	10.304550	16
45	9.695671	9.938619	9.757052	10.242948	10.061381	10.304329	15
46	9.695892	9.938547	9.757345	10.242655	10.061453	10.304108	14
47	9.696113	9.938475	9.757638	10.242362	10.061525	10.303887	13
48	9.696334	9.938402	9.757931	10.242069	10.061598	10.303666	12
49	9.696554	9.938330	9.758224	10.241776	10.061670	10.303446	11
50	9.696775	9.938258	9.758517	10.241483	10.061742	10.303225	10
51	9.696995	9.938185	9.758810	10.241190	10.061815	10.303005	9
52	9.697215	9.938113	9.759102	10.240898	10.061887	10.302785	8
53	9.697435	9.938040	9.759395	10.240605	10.061960	10.302565	7
54	9.697654	9.937967	9.759687	10.240313	10.062033	10.302346	6
55	9.697874	9.937895	9.759979	10.240021	10.062105	10.302126	5
56	9.698094	9.937822	9.760272	10.239728	10.062178	10.301906	4
57	9.698313	9.937749	9.760564	10.239436	10.062251	10.301687	3
58	9.698532	9.937676	9.760856	10.239144	10.062324	10.301468	2
59	9.698751	9.937604	9.761148	10.238852	10.062396	10.301249	1
60	9.698970	9.937531	9.761439	10.238561	10.062469	10.301030	0
M	Co-sine.	Sine.	Co-tang.	Tang.	Co-sec.	Secant.	M

60 Degrees.

30 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang.	Secant.	Co-sec.	M
0	9.698970	9.937531	9.761439	10.238561	10.062469	10.301030	60
1	9.699189	9.937458	9.761731	10.238269	10.062542	10.300811	59
2	9.699407	9.937385	9.762023	10.237977	10.062615	10.300593	58
3	9.699626	9.937312	9.762314	10.237686	10.062688	10.300374	57
4	9.699844	9.937238	9.762606	10.237394	10.062762	10.300156	56
5	9.700062	9.937165	9.762897	10.237103	10.062835	10.299938	55
6	9.700280	9.937092	9.763188	10.236812	10.062908	10.299720	54
7	9.700498	9.937019	9.763479	10.236521	10.062981	10.299502	53
8	9.700716	9.936946	9.763770	10.236230	10.063054	10.299284	52
9	9.700933	9.936872	9.764061	10.235939	10.063128	10.299067	51
10	9.701151	9.936799	9.764352	10.235648	10.063201	10.298849	50
11	9.701368	9.936725	9.764643	10.235357	10.063275	10.298632	49
12	9.701585	9.936652	9.764933	10.235067	10.063348	10.298415	48
13	9.701802	9.936578	9.765224	10.234776	10.063422	10.298198	47
14	9.702019	9.936505	9.765514	10.234486	10.063495	10.297981	46
15	9.702236	9.936431	9.765805	10.234195	10.063569	10.297764	45
16	9.702452	9.936357	9.766095	10.233905	10.063643	10.297548	44
17	9.702669	9.936284	9.766385	10.233615	10.063716	10.297331	43
18	9.702885	9.936210	9.766675	10.233325	10.063790	10.297115	42
19	9.703101	9.936136	9.766965	10.233035	10.063864	10.296899	41
20	9.703317	9.936062	9.767255	10.232745	10.063938	10.296683	40
21	9.703533	9.935988	9.767545	10.232455	10.064012	10.296467	39
22	9.703749	9.935914	9.767834	10.232166	10.064086	10.296251	38
23	9.703964	9.935840	9.768124	10.231876	10.064160	10.296036	37
24	9.704179	9.935766	9.768414	10.231586	10.064234	10.295821	36
25	9.704395	9.935692	9.768703	10.231297	10.064308	10.295605	35
26	9.704610	9.935618	9.768992	10.231008	10.064382	10.295390	34
27	9.704825	9.935543	9.769281	10.230719	10.064457	10.295175	33
28	9.705040	9.935469	9.769570	10.230430	10.064531	10.294960	32
29	9.705254	9.935395	9.769860	10.230140	10.064605	10.294746	31
30	9.705469	9.935320	9.770148	10.229852	10.064680	10.294531	30
31	9.705683	9.935246	9.770437	10.229563	10.064754	10.294317	29
32	9.705898	9.935171	9.770726	10.229274	10.064829	10.294102	28
33	9.706112	9.935097	9.771015	10.228985	10.064903	10.293888	27
34	9.706326	9.935022	9.771303	10.228697	10.064978	10.293674	26
35	9.706539	9.934948	9.771592	10.228408	10.065052	10.293461	25
36	9.706753	9.934873	9.771880	10.228120	10.065127	10.293247	24
37	9.706967	9.934798	9.772168	10.227832	10.065202	10.293033	23
38	9.707180	9.934723	9.772457	10.227543	10.065277	10.292820	22
39	9.707393	9.934649	9.772745	10.227255	10.065351	10.292607	21
40	9.707606	9.934574	9.773033	10.226967	10.065426	10.292394	20
41	9.707819	9.934499	9.773321	10.226679	10.065501	10.292181	19
42	9.708032	9.934424	9.773608	10.226392	10.065576	10.291968	18
43	9.708245	9.934349	9.773896	10.226104	10.065651	10.291755	17
44	9.708458	9.934274	9.774184	10.225816	10.065726	10.291542	16
45	9.708670	9.934199	9.774471	10.225529	10.065801	10.291330	15
46	9.708882	9.934123	9.774759	10.225241	10.065877	10.291118	14
47	9.709094	9.934048	9.775046	10.224954	10.065952	10.290906	13
48	9.709306	9.933973	9.775333	10.224667	10.066027	10.290694	12
49	9.709518	9.933898	9.775621	10.224379	10.066102	10.290482	11
50	9.709730	9.933822	9.775908	10.224092	10.066178	10.290270	10
51	9.709941	9.933747	9.776195	10.223805	10.066253	10.290059	9
52	9.710153	9.933671	9.776482	10.223518	10.066329	10.289847	8
53	9.710364	9.933596	9.776769	10.223231	10.066404	10.289636	7
54	9.710575	9.933520	9.777055	10.222945	10.066480	10.289425	6
55	9.710786	9.933445	9.777342	10.222658	10.066555	10.289214	5
56	9.710997	9.933369	9.777628	10.222372	10.066631	10.289003	4
57	9.711208	9.933293	9.777915	10.222085	10.066707	10.288792	3
58	9.711419	9.933217	9.778201	10.221799	10.066783	10.288581	2
59	9.711629	9.933141	9.778487	10.221513	10.066859	10.288371	1
60	9.711839	9.933066	9.778774	10.221226	10.066934	10.288161	0
M	Co-sine.	Sine.	Cotang.	Tang.	Co-sec.	Secant.	M

59 Degrees.

31 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang.	Secant.	Co-sec.	M
0	9.711839	9.933066	9.778774	10.221226	10.066934	10.288161	60
1	9.712050	9.932990	9.779060	10.220940	10.067010	10.287950	59
2	9.712260	9.932914	9.779346	10.220654	10.067086	10.287740	58
3	9.712469	9.932838	9.779632	10.220368	10.067162	10.287531	57
4	9.712679	9.932762	9.779918	10.220082	10.067238	10.287321	56
5	9.712889	9.932685	9.780203	10.219797	10.067315	10.287111	55
6	9.713098	9.932609	9.780489	10.219511	10.067391	10.286902	54
7	9.713308	9.932533	9.780775	10.219225	10.067467	10.286692	53
8	9.713517	9.932457	9.781060	10.218940	10.067543	10.286483	52
9	9.713726	9.932380	9.781346	10.218654	10.067620	10.286274	51
10	9.713935	9.932304	9.781631	10.218369	10.067696	10.286065	50
11	9.714144	9.932228	9.781916	10.218084	10.067772	10.285856	49
12	9.714352	9.932151	9.782201	10.217799	10.067849	10.285648	48
13	9.714561	9.932075	9.782486	10.217514	10.067925	10.285439	47
14	9.714769	9.931998	9.782771	10.217229	10.068002	10.285231	46
15	9.714978	9.931921	9.783056	10.216944	10.068079	10.285022	45
16	9.715186	9.931845	9.783341	10.216659	10.068155	10.284814	44
17	9.715394	9.931768	9.783626	10.216374	10.068232	10.284606	43
18	9.715602	9.931691	9.783910	10.216090	10.068309	10.284398	42
19	9.715809	9.931614	9.784195	10.215805	10.068386	10.284191	41
20	9.716017	9.931537	9.784479	10.215521	10.068463	10.283983	40
21	9.716224	9.931460	9.784764	10.215236	10.068540	10.283776	39
22	9.716432	9.931383	9.785048	10.214952	10.068617	10.283568	38
23	9.716639	9.931306	9.785332	10.214668	10.068694	10.283361	37
24	9.716846	9.931229	9.785616	10.214384	10.068771	10.283154	36
25	9.717053	9.931152	9.785900	10.214100	10.068848	10.282947	35
26	9.717259	9.931075	9.786184	10.213816	10.068925	10.282741	34
27	9.717466	9.930998	9.786468	10.213532	10.069002	10.282534	33
28	9.717673	9.930921	9.786752	10.213248	10.069079	10.282327	32
29	9.717879	9.930843	9.787036	10.212964	10.069157	10.282121	31
30	9.718085	9.930766	9.787319	10.212681	10.069234	10.281915	30
31	9.718291	9.930688	9.787603	10.212397	10.069312	10.281709	29
32	9.718497	9.930611	9.787886	10.212114	10.069389	10.281503	28
33	9.718703	9.930533	9.788170	10.211830	10.069467	10.281297	27
34	9.718909	9.930456	9.788453	10.211547	10.069544	10.281091	26
35	9.719114	9.930378	9.788736	10.211264	10.069622	10.280886	25
36	9.719320	9.930300	9.789019	10.210981	10.069700	10.280680	24
37	9.719525	9.930223	9.789302	10.210698	10.069777	10.280475	23
38	9.719730	9.930145	9.789585	10.210415	10.069855	10.280270	22
39	9.719935	9.930067	9.789868	10.210132	10.069933	10.280065	21
40	9.720140	9.929989	9.790151	10.209849	10.070011	10.279860	20
41	9.720345	9.929911	9.790433	10.209567	10.070089	10.279655	19
42	9.720549	9.929833	9.790716	10.209284	10.070167	10.279451	18
43	9.720754	9.929755	9.790999	10.209001	10.070245	10.279246	17
44	9.720958	9.929677	9.791281	10.208719	10.070323	10.279042	16
45	9.721162	9.929599	9.791563	10.208437	10.070401	10.278838	15
46	9.721366	9.929521	9.791846	10.208154	10.070479	10.278634	14
47	9.721570	9.929442	9.792128	10.207872	10.070558	10.278430	13
48	9.721774	9.929364	9.792410	10.207590	10.070636	10.278226	12
49	9.721978	9.929286	9.792692	10.207308	10.070714	10.278022	11
50	9.722181	9.929207	9.792974	10.207026	10.070793	10.277819	10
51	9.722385	9.929129	9.793256	10.206744	10.070871	10.277615	9
52	9.722588	9.929050	9.793538	10.206462	10.070950	10.277412	8
53	9.722791	9.928972	9.793819	10.206181	10.071028	10.277209	7
54	9.722994	9.928893	9.794101	10.205899	10.071107	10.277006	6
55	9.723197	9.928815	9.794383	10.205617	10.071185	10.276803	5
56	9.723400	9.928736	9.794664	10.205336	10.071264	10.276600	4
57	9.723603	9.928657	9.794945	10.205055	10.071343	10.276397	3
58	9.723805	9.928578	9.795227	10.204773	10.071422	10.276195	2
59	9.724007	9.928499	9.795508	10.204492	10.071501	10.275993	1
60	9.724210	9.928420	9.795789	10.204211	10.071580	10.275790	0
M	Co-sine.	Sine.	Co-tang.	Tang.	Co-sec.	Secant.	M

58 Degrees.

32 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang.	Secant.	Co-sec.	M
0	9.724210	9.928420	9.795789	10.204211	10.071580	10.275790	60
1	9.724412	9.928342	9.796070	10.203930	10.071658	10.275588	59
2	9.724614	9.928263	9.796351	10.203649	10.071737	10.275386	58
3	9.724816	9.928183	9.796632	10.203368	10.071817	10.275184	57
4	9.725017	9.928104	9.796913	10.203087	10.071896	10.274983	56
5	9.725219	9.928025	9.797194	10.202806	10.071975	10.274781	55
6	9.725420	9.927946	9.797475	10.202525	10.072054	10.274580	54
7	9.725622	9.927867	9.797755	10.202245	10.072133	10.274378	53
8	9.725823	9.927787	9.798036	10.201964	10.072213	10.274177	52
9	9.726024	9.927708	9.798316	10.201684	10.072292	10.273976	51
10	9.726225	9.927629	9.798596	10.201404	10.072371	10.273775	50
11	9.726426	9.927549	9.798877	10.201123	10.072451	10.273574	49
12	9.726626	9.927470	9.799157	10.200843	10.072530	10.273374	48
13	9.726827	9.927390	9.799437	10.200563	10.072610	10.273173	47
14	9.727027	9.927310	9.799717	10.200283	10.072690	10.272973	46
15	9.727228	9.927231	9.799997	10.200003	10.072769	10.272772	45
16	9.727428	9.927151	9.800277	10.199723	10.072849	10.272572	44
17	9.727628	9.927071	9.800557	10.199443	10.072929	10.272372	43
18	9.727828	9.926991	9.800836	10.199164	10.073009	10.272172	42
19	9.728027	9.926911	9.801116	10.198884	10.073089	10.271973	41
20	9.728227	9.926831	9.801396	10.198604	10.073169	10.271773	40
21	9.728427	9.926751	9.801675	10.198325	10.073249	10.271573	39
22	9.728626	9.926671	9.801955	10.198045	10.073329	10.271374	38
23	9.728825	9.926591	9.802234	10.197766	10.073409	10.271175	37
24	9.729024	9.926511	9.802513	10.197487	10.073489	10.270976	36
25	9.729223	9.926431	9.802792	10.197208	10.073569	10.270777	35
26	9.729422	9.926351	9.803072	10.196928	10.073649	10.270578	34
27	9.729621	9.926270	9.803351	10.196649	10.073730	10.270379	33
28	9.729820	9.926190	9.803630	10.196370	10.073810	10.270180	32
29	9.730018	9.926110	9.803908	10.196092	10.073890	10.269982	31
30	9.730217	9.926029	9.804187	10.195813	10.073971	10.269783	30
31	9.730415	9.925949	9.804466	10.195534	10.074051	10.269585	29
32	9.730613	9.925868	9.804745	10.195255	10.074132	10.269387	28
33	9.730811	9.925788	9.805023	10.194977	10.074212	10.269189	27
34	9.731009	9.925707	9.805302	10.194698	10.074293	10.268991	26
35	9.731206	9.925626	9.805580	10.194420	10.074374	10.268794	25
36	9.731404	9.925545	9.805859	10.194141	10.074455	10.268596	24
37	9.731602	9.925465	9.806137	10.193863	10.074535	10.268398	23
38	9.731799	9.925384	9.806415	10.193585	10.074616	10.268201	22
39	9.731996	9.925303	9.806693	10.193307	10.074697	10.268004	21
40	9.732193	9.925222	9.806971	10.193029	10.074778	10.267807	20
41	9.732390	9.925141	9.807249	10.192751	10.074859	10.267610	19
42	9.732587	9.925060	9.807527	10.192473	10.074940	10.267413	18
43	9.732784	9.924979	9.807805	10.192195	10.075021	10.267216	17
44	9.732980	9.924897	9.808083	10.191917	10.075103	10.267020	16
45	9.733177	9.924816	9.808361	10.191639	10.075184	10.266823	15
46	9.733373	9.924735	9.808638	10.191362	10.075265	10.266627	14
47	9.733569	9.924654	9.808916	10.191084	10.075346	10.266431	13
48	9.733765	9.924572	9.809193	10.190807	10.075428	10.266235	12
49	9.733961	9.924491	9.809471	10.190529	10.075509	10.266039	11
50	9.734157	9.924409	9.809748	10.190252	10.075591	10.265843	10
51	9.734353	9.924328	9.810025	10.189975	10.075672	10.265647	9
52	9.734549	9.924246	9.810302	10.189698	10.075754	10.265451	8
53	9.734744	9.924164	9.810580	10.189420	10.075836	10.265256	7
54	9.734939	9.924083	9.810857	10.189143	10.075917	10.265061	6
55	9.735135	9.924001	9.811134	10.188866	10.075999	10.264865	5
56	9.735330	9.923919	9.811410	10.188590	10.076081	10.264670	4
57	9.735525	9.923837	9.811687	10.188313	10.076163	10.264475	3
58	9.735719	9.923755	9.811964	10.188036	10.076245	10.264281	2
59	9.735914	9.923673	9.812241	10.187759	10.076327	10.264086	1
60	9.736109	9.923591	9.812517	10.187483	10.076409	10.263891	0
M	Co-sine.	Sine.	Co-tang.	Tang.	Co-sec.	Secant.	M

57 Degrees.

33 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang.	Secant.	Co-sec	M
0	9.736109	9.923591	9.812517	10.187483	10.076409	10.263891	60
1	9.736303	9.923509	9.812794	10.187206	10.076491	10.263697	59
2	9.736498	9.923427	9.813070	10.186930	10.076573	10.263502	58
3	9.736692	9.923345	9.813347	10.186653	10.076655	10.263308	57
4	9.736886	9.923263	9.813623	10.186377	10.076737	10.263114	56
5	9.737080	9.923181	9.813899	10.186101	10.076819	10.262920	55
6	9.737274	9.923098	9.814175	10.185825	10.076902	10.262726	54
7	9.737467	9.923016	9.814452	10.185548	10.076984	10.262533	53
8	9.737661	9.922933	9.814728	10.185272	10.077067	10.262339	52
9	9.737855	9.922851	9.815004	10.184996	10.077149	10.262145	51
10	9.738048	9.922768	9.815279	10.184721	10.077232	10.261952	50
11	9.738241	9.922686	9.815555	10.184445	10.077314	10.261759	49
12	9.738434	9.922603	9.815831	10.184169	10.077397	10.261566	48
13	9.738627	9.922520	9.816107	10.183893	10.077480	10.261373	47
14	9.738820	9.922438	9.816382	10.183618	10.077562	10.261180	46
15	9.739013	9.922355	9.816658	10.183342	10.077645	10.260987	45
16	9.739206	9.922272	9.816933	10.183067	10.077728	10.260794	44
17	9.739398	9.922189	9.817209	10.182791	10.077811	10.260602	43
18	9.739590	9.922106	9.817484	10.182516	10.077894	10.260410	42
19	9.739783	9.922023	9.817759	10.182241	10.077977	10.260217	41
20	9.739975	9.921940	9.818035	10.181965	10.078060	10.260025	40
21	9.740167	9.921857	9.818310	10.181690	10.078143	10.259833	39
22	9.740359	9.921774	9.818585	10.181415	10.078226	10.259641	38
23	9.740550	9.921691	9.818860	10.181140	10.078309	10.259450	37
24	9.740742	9.921607	9.819135	10.180865	10.078393	10.259258	36
25	9.740934	9.921524	9.819410	10.180590	10.078476	10.259066	35
26	9.741125	9.921441	9.819684	10.180316	10.078559	10.258875	34
27	9.741316	9.921357	9.819959	10.180041	10.078643	10.258684	33
28	9.741508	9.921274	9.820234	10.179766	10.078726	10.258492	32
29	9.741699	9.921190	9.820508	10.179492	10.078810	10.258301	31
30	9.741889	9.921107	9.820783	10.179217	10.078893	10.258111	30
31	9.742080	9.921023	9.821057	10.178943	10.078977	10.257920	29
32	9.742271	9.920939	9.821332	10.178668	10.079061	10.257729	28
33	9.742462	9.920856	9.821606	10.178394	10.079144	10.257538	27
34	9.742652	9.920772	9.821880	10.178120	10.079228	10.257348	26
35	9.742842	9.920688	9.822154	10.177846	10.079312	10.257158	25
36	9.743033	9.920604	9.822429	10.177571	10.079396	10.256967	24
37	9.743223	9.920520	9.822703	10.177297	10.079480	10.256777	23
38	9.743413	9.920436	9.822977	10.177023	10.079564	10.256587	22
39	9.743602	9.920352	9.823250	10.176750	10.079648	10.256398	21
40	9.743792	9.920268	9.823524	10.176476	10.079732	10.256208	20
41	9.743982	9.920184	9.823798	10.176202	10.079816	10.256018	19
42	9.744171	9.920099	9.824072	10.175928	10.079901	10.255829	18
43	9.744361	9.920015	9.824345	10.175655	10.079985	10.255639	17
44	9.744550	9.919931	9.824619	10.175381	10.080069	10.255450	16
45	9.744739	9.919846	9.824893	10.175107	10.080154	10.255261	15
46	9.744928	9.919762	9.825166	10.174834	10.080238	10.255072	14
47	9.745117	9.919677	9.825439	10.174561	10.080323	10.254883	13
48	9.745306	9.919593	9.825713	10.174287	10.080407	10.254694	12
49	9.745494	9.919508	9.825986	10.174014	10.080492	10.254506	11
50	9.745683	9.919424	9.826259	10.173741	10.080576	10.254317	10
51	9.745871	9.919339	9.826532	10.173468	10.080661	10.254129	9
52	9.746060	9.919254	9.826805	10.173195	10.080746	10.253940	8
53	9.746248	9.919169	9.827078	10.172922	10.080831	10.253752	7
54	9.746436	9.919085	9.827351	10.172649	10.080915	10.253564	6
55	9.746624	9.919000	9.827624	10.172376	10.081000	10.253376	5
56	9.746812	9.918915	9.827897	10.172103	10.081085	10.253188	4
57	9.746999	9.918830	9.828170	10.171830	10.081170	10.253001	3
58	9.747187	9.918745	9.828442	10.171558	10.081255	10.252813	2
59	9.747374	9.918659	9.828715	10.171285	10.081341	10.252626	1
60	9.747562	9.918574	9.828987	10.171013	10.081426	10.252438	0
M	Co-sine	Sine.	Co-tang.	Tang.	Co-sec.	Secant	M

56 Degrees.

34 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang.	Secant	Co-sec.	M
0	9.747562	9.918574	9.828987	10.171013	10.081426	10.252438	60
1	9.747749	9.918489	9.829260	10.170740	10.081511	10.252251	59
2	9.747936	9.918404	9.829532	10.170468	10.081596	10.252064	58
3	9.748123	9.918318	9.829805	10.170195	10.081682	10.251877	57
4	9.748310	9.918233	9.830077	10.169923	10.081767	10.251690	56
5	9.748497	9.918147	9.830349	10.169651	10.081853	10.251503	55
6	9.748683	9.918062	9.830621	10.169379	10.081938	10.251317	54
7	9.748870	9.917976	9.830893	10.169107	10.082024	10.251130	53
8	9.749056	9.917891	9.831165	10.168835	10.082109	10.250944	52
9	9.749243	9.917805	9.831437	10.168563	10.082195	10.250757	51
10	9.749429	9.917719	9.831709	10.168291	10.082281	10.250571	50
11	9.749615	9.917634	9.831981	10.168019	10.082366	10.250385	49
12	9.749801	9.917548	9.832253	10.167747	10.082452	10.250199	48
13	9.749987	9.917462	9.832525	10.167475	10.082538	10.250013	47
14	9.750172	9.917376	9.832796	10.167204	10.082624	10.249828	46
15	9.750358	9.917290	9.833068	10.166932	10.082710	10.249642	45
16	9.750543	9.917204	9.833339	10.166661	10.082796	10.249457	44
17	9.750729	9.917118	9.833611	10.166389	10.082882	10.249271	43
18	9.750914	9.917032	9.833882	10.166118	10.082968	10.249086	42
19	9.751099	9.916946	9.834154	10.165846	10.083054	10.248901	41
20	9.751284	9.916859	9.834425	10.165575	10.083141	10.248716	40
21	9.751469	9.916773	9.834696	10.165304	10.083227	10.248531	39
22	9.751654	9.916687	9.834967	10.165033	10.083313	10.248346	38
23	9.751839	9.916600	9.835238	10.164762	10.083400	10.248161	37
24	9.752023	9.916514	9.835509	10.164491	10.083486	10.247977	36
25	9.752208	9.916427	9.835780	10.164220	10.083573	10.247792	35
26	9.752392	9.916341	9.836051	10.163949	10.083659	10.247608	34
27	9.752576	9.916254	9.836322	10.163678	10.083746	10.247424	33
28	9.752760	9.916167	9.836593	10.163407	10.083833	10.247240	32
29	9.752944	9.916081	9.836864	10.163136	10.083919	10.247056	31
30	9.753128	9.915994	9.837134	10.162866	10.084006	10.246872	30
31	9.753312	9.915907	9.837405	10.162595	10.084093	10.246688	29
32	9.753495	9.915820	9.837675	10.162325	10.084180	10.246505	28
33	9.753679	9.915733	9.837946	10.162054	10.084267	10.246321	27
34	9.753862	9.915646	9.838216	10.161784	10.084354	10.246138	26
35	9.754046	9.915559	9.838487	10.161513	10.084441	10.245954	25
36	9.754229	9.915472	9.838757	10.161243	10.084528	10.245771	24
37	9.754412	9.915385	9.839027	10.160973	10.084615	10.245588	23
38	9.754595	9.915297	9.839297	10.160703	10.084703	10.245405	22
39	9.754778	9.915210	9.839568	10.160432	10.084790	10.245222	21
40	9.754960	9.915123	9.839838	10.160162	10.084877	10.245040	20
41	9.755143	9.915035	9.840108	10.159892	10.084965	10.244857	19
42	9.755326	9.914948	9.840378	10.159622	10.085052	10.244674	18
43	9.755508	9.914860	9.840647	10.159353	10.085140	10.244492	17
44	9.755690	9.914773	9.840917	10.159083	10.085227	10.244310	16
45	9.755872	9.914685	9.841187	10.158813	10.085315	10.244128	15
46	9.756054	9.914598	9.841457	10.158543	10.085402	10.243946	14
47	9.756236	9.914510	9.841726	10.158274	10.085490	10.243764	13
48	9.756418	9.914422	9.841996	10.158004	10.085578	10.243582	12
49	9.756600	9.914334	9.842266	10.157734	10.085666	10.243400	11
50	9.756782	9.914246	9.842535	10.157465	10.085754	10.243218	10
51	9.756963	9.914158	9.842805	10.157195	10.085842	10.243037	9
52	9.757144	9.914070	9.843074	10.156926	10.085930	10.242856	8
53	9.757326	9.913982	9.843343	10.156657	10.086018	10.242674	7
54	9.757507	9.913894	9.843612	10.156388	10.086106	10.242493	6
55	9.757688	9.913806	9.843882	10.156118	10.086194	10.242312	5
56	9.757869	9.913718	9.844151	10.155849	10.086282	10.242131	4
57	9.758050	9.913630	9.844420	10.155580	10.086370	10.241950	3
58	9.758230	9.913541	9.844689	10.155311	10.086459	10.241770	2
59	9.758411	6.913453	9.844958	10.155042	10.086547	10.241589	1
60	9.758591	9.913365	9.845227	10.154773	10.086635	10.241409	0
M	Co-sine.	Sine.	Co-tang	Tang.	Co-sec	Secant.	M

55 Degrees.

35 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang.	Secant.	Co-sec.	M
0	9.758591	9.913365	9.845227	10.154773	10.086635	10.241409	60
1	9.758772	9.913276	9.845496	10.154504	10.086724	10.241228	59
2	9.758952	9.913187	9.845764	10.154236	10.086813	10.241048	58
3	9.759132	9.913099	9.846033	10.153967	10.086901	10.240868	57
4	9.759312	9.913010	9.846302	10.153698	10.086990	10.240688	56
5	9.759492	9.912922	9.846570	10.153430	10.087078	10.240508	55
6	9.759672	9.912833	9.846839	10.153161	10.087167	10.240328	54
7	9.759852	9.912744	9.847107	10.152893	10.087256	10.240148	53
8	9.760031	9.912655	9.847376	10.152624	10.087345	10.239969	52
9	9.760211	9.912566	9.847644	10.152356	10.087434	10.239789	51
10	9.760390	9.912477	9.847913	10.152087	10.087523	10.239610	50
11	9.760569	9.912388	9.848181	10.151819	10.087612	10.239431	49
12	9.760748	9.912299	9.848449	10.151551	10.087701	10.239252	48
13	9.760927	9.912210	9.848717	10.151283	10.087790	10.239073	47
14	9.761106	9.912121	9.848986	10.151014	10.087879	10.238894	46
15	9.761285	9.912031	9.849254	10.150746	10.087969	10.238715	45
16	9.761464	9.911942	9.849522	10.150478	10.088058	10.238536	44
17	9.761642	9.911853	9.849790	10.150210	10.088147	10.238358	43
18	9.761821	9.911763	9.850058	10.149942	10.088237	10.238179	42
19	9.761999	9.911674	9.850325	10.149675	10.088326	10.238001	41
20	9.762177	9.911584	9.850593	10.149407	10.088416	10.237823	40
21	9.762356	9.911495	9.850861	10.149139	10.088505	10.237644	39
22	9.762534	9.911405	9.851129	10.148871	10.088595	10.237466	38
23	9.762712	9.911315	9.851396	10.148604	10.088685	10.237288	37
24	9.762889	9.911226	9.851664	10.148336	10.088774	10.237111	36
25	9.763067	9.911136	9.851931	10.148069	10.088864	10.236933	35
26	9.763245	9.911046	9.852199	10.147801	10.088954	10.236755	34
27	9.763422	9.910956	9.852466	10.147534	10.089044	10.236578	33
28	9.763600	9.910866	9.852733	10.147267	10.089134	10.236400	32
29	9.763777	9.910776	9.853001	10.146999	10.089224	10.236223	31
30	9.763954	9.910686	9.853268	10.146732	10.089314	10.236046	30
31	9.764131	9.910596	9.853535	10.146465	10.089404	10.235869	29
32	9.764308	9.910506	9.853802	10.146198	10.089494	10.235692	28
33	9.764485	9.910415	9.854069	10.145931	10.089585	10.235515	27
34	9.764662	9.910325	9.854336	10.145664	10.089675	10.235338	26
35	9.764838	9.910235	9.854603	10.145397	10.089765	10.235162	25
36	9.765015	9.910144	9.854870	10.145130	10.089856	10.234985	24
37	9.765191	9.910054	9.855137	10.144863	10.089946	10.234809	23
38	9.765367	9.909963	9.855404	10.144596	10.090037	10.234633	22
39	9.765544	9.909873	9.855671	10.144329	10.090127	10.234456	21
40	9.765720	9.909782	9.855938	10.144062	10.090218	10.234280	20
41	9.765896	9.909691	9.856204	10.143796	10.090309	10.234104	19
42	9.766072	9.909601	9.856471	10.143529	10.090399	10.233928	18
43	9.766247	9.909510	9.856737	10.143263	10.090490	10.233753	17
44	9.766423	9.909419	9.857004	10.142996	10.090581	10.233577	16
45	9.766598	9.909328	9.857270	10.142730	10.090672	10.233402	15
46	9.766774	9.909237	9.857537	10.142463	10.090763	10.233226	14
47	9.766949	9.909146	9.857803	10.142197	10.090854	10.233051	13
48	9.767124	9.909055	9.858069	10.141931	10.090945	10.232876	12
49	9.767300	9.908964	9.858336	10.141664	10.091036	10.232700	11
50	9.767475	9.908873	9.858602	10.141398	10.091127	10.232525	10
51	9.767649	9.908781	9.858868	10.141132	10.091219	10.232351	9
52	9.767824	9.908690	9.859134	10.140866	10.091310	10.232176	8
53	9.767999	9.908599	9.859400	10.140600	10.091401	10.232001	7
54	9.768173	9.908507	9.859666	10.140334	10.091493	10.231827	6
55	9.768348	9.908416	9.859932	10.140068	10.091584	10.231652	5
56	9.768522	9.908324	9.860198	10.139802	10.091676	10.231478	4
57	9.768697	9.908233	9.860464	10.139536	10.091767	10.231303	3
58	9.768871	9.908141	9.860730	10.139270	10.091859	10.231129	2
59	9.769045	9.908049	9.860995	10.139005	10.091951	10.230955	1
60	9.769219	9.907958	9.861261	10.138739	10.092042	10.230781	0
M	Co-sine.	Sine.	Co-tang.	Tang.	Co-sec.	Secant	M

54 Degrees.

36 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang	Secant.	Co-sec.	M
0	9.769219	9.907958	9.861261	10.138739	10.092042	10.230781	60
1	9.769393	9.907866	9.861527	10.138473	10.092134	10.230607	59
2	9.769566	9.907774	9.861792	10.138208	10.092226	10.230434	58
3	9.769740	9.907682	9.862058	10.137942	10.092318	10.230260	57
4	9.769913	9.907590	9.862323	10.137677	10.092410	10.230087	56
5	9.770087	9.907498	9.862589	10.137411	10.092502	10.229913	55
6	9.770260	9.907406	9.862854	10.137146	10.092594	10.229740	54
7	9.770433	9.907314	9.863119	10.136881	10.092686	10.229567	53
8	9.770606	9.907222	9.863385	10.136615	10.092778	10.229394	52
9	9.770779	9.907129	9.863650	10.136350	10.092871	10.229221	51
10	9.770952	9.907037	9.863915	10.136085	10.092963	10.229048	50
11	9.771125	9.906945	9.864180	10.135820	10.093055	10.228875	49
12	9.771298	9.906852	9.864445	10.135555	10.093148	10.228702	48
13	9.771470	9.906760	9.864710	10.135290	10.093240	10.228530	47
14	9.771643	9.906667	9.864975	10.135025	10.093333	10.228357	46
15	9.771815	9.906575	9.865240	10.134760	10.093425	10.228185	45
16	9.771987	9.906482	9.865505	10.134495	10.093518	10.228013	44
17	9.772159	9.906389	9.865770	10.134230	10.093611	10.227841	43
18	9.772331	9.906296	9.866035	10.133965	10.093704	10.227669	42
19	9.772503	9.906204	9.866300	10.133700	10.093796	10.227497	41
20	9.772675	9.906111	9.866564	10.133436	10.093889	10.227325	40
21	9.772847	9.906018	9.866829	10.133171	10.093982	10.227153	39
22	9.773018	9.905925	9.867094	10.132906	10.094075	10.226982	38
23	9.773190	9.905832	9.867358	10.132642	10.094168	10.226810	37
24	9.773361	9.905739	9.867623	10.132377	10.094261	10.226639	36
25	9.773533	9.905645	9.867687	10.132113	10.094355	10.226467	35
26	9.773704	9.905552	9.868152	10.131848	10.094448	10.226296	34
27	9.773875	9.905459	9.868416	10.131584	10.094541	10.226125	33
28	9.774046	9.905366	9.868680	10.131320	10.094634	10.225954	32
29	9.774217	9.905272	9.868945	10.131055	10.094728	10.225783	31
30	9.774388	9.905179	9.869209	10.130791	10.094821	10.225612	30
31	9.774558	9.905085	9.869473	10.130527	10.094915	10.225442	29
32	9.774729	9.904992	9.869737	10.130263	10.095008	10.225271	28
33	9.774899	9.904898	9.870001	10.129999	10.095102	10.225101	27
34	9.775070	9.904804	9.870265	10.129735	10.095196	10.224930	26
35	9.775240	9.904711	9.870529	10.129471	10.095289	10.224760	25
36	9.775410	9.904617	9.870793	10.129207	10.095383	10.224590	24
37	9.775580	9.904523	9.871057	10.128943	10.095477	10.224420	23
38	9.775750	9.904429	9.871321	10.128679	10.095571	10.224250	22
39	9.775920	9.904335	9.871585	10.128415	10.095665	10.224080	21
40	9.776090	9.904241	9.871849	10.128151	10.095759	10.223910	20
41	9.776259	9.904147	9.872112	10.127888	10.095853	10.223741	19
42	9.776429	9.904053	9.872376	10.127624	10.095947	10.223571	18
43	9.776598	9.903959	9.872640	10.127360	10.096041	10.223402	17
44	9.776768	9.903864	9.872903	10.127097	10.096136	10.223232	16
45	9.776937	9.903770	9.873167	10.126833	10.096230	10.223063	15
46	9.777106	9.903676	9.873430	10.126570	10.096324	10.222894	14
47	9.777275	9.903581	9.873694	10.126306	10.096419	10.222725	13
48	9.777444	9.903487	9.873957	10.126043	10.096513	10.222556	12
49	9.777613	9.903392	9.874220	10.125780	10.096608	10.222387	11
50	9.777781	9.903298	9.874484	10.125516	10.096702	10.222219	10
51	9.777950	9.903203	9.874747	10.125253	10.096797	10.222050	9
52	9.778119	9.903108	9.875010	10.124990	10.096892	10.221881	8
53	9.778287	9.903014	9.875273	10.124727	10.096986	10.221713	7
54	9.778455	9.902919	9.875536	10.124464	10.097081	10.221545	6
55	9.778624	9.902824	9.[illegible]5800	10.124200	10.097176	10.221376	5
56	9.778792	9.902729	9.876063	10.123937	10.097271	10.221208	4
57	9.778960	9.902634	9.876326	10.123674	10.097366	10.221040	3
58	9.779128	9.902539	9.876589	10.123411	10.097461	10.220872	2
59	9.779295	9.902444	9.876851	10.123149	10.097556	10.220705	1
60	9.779463	9.902349	9.877114	10.122886	10.097651	10.220537	0
M	Co-sine.	Sine.	Co-tang	Tang	Co-sec	Secant	M

53 Degrees.

37 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang.	Secant.	Co-sec.	M
0	9.779463	9.902349	9.877114	10.122886	10.097651	10.220537	60
1	9.779631	9.902253	9.877377	10.122623	10.097747	10.220369	59
2	9.779798	9.902158	9.877640	10.122360	10.097842	10.220202	58
3	9.779966	9.902063	9.877903	10.122097	10.097937	10.220034	57
4	9.780133	9.901967	9.878165	10.121835	10.098033	10.219867	56
5	9.780300	9.901872	9.878428	10.121572	10.098128	10.219700	55
6	9.780467	9.901776	9.878691	10.121309	10.098224	10.219533	54
7	9.780634	9.901681	9.878953	10.121047	10.098319	10.219366	53
8	9.780801	9.901585	9.879216	10.120784	10.098415	10.219199	52
9	9.780968	9.901490	9.879478	10.120522	10.098510	10.219032	51
10	9.781134	9.901394	9.879741	10.120259	10.098606	10.218866	50
11	9.781301	9.901298	9.880003	10.119997	10.098702	10.218699	49
12	9.781468	9.901202	9.880265	10.119735	10.098798	10.218532	48
13	9.781634	9.901106	9.880528	10.119472	10.098894	10.218366	47
14	9.781800	9.901010	9.880790	10.119210	10.098990	10.218200	46
15	9.781966	9.900914	9.881052	10.118948	10.099086	10.218034	45
16	9.782132	9.900818	9.881314	10.118686	10.099182	10.217868	44
17	9.782298	9.900722	9.881576	10.118424	10.099278	10.217702	43
18	9.782464	9.900626	9.881839	10.118161	10.099374	10.217536	42
19	9.782630	9.900529	9.882101	10.117899	10.099471	10.217370	41
20	9.782796	9.900433	9.882363	10.117637	10.099567	10.217204	40
21	9.782961	9.900337	9.882625	10.117375	10.099663	10.217039	39
22	9.783127	9.900240	9.882887	10.117113	10.099760	10.216873	38
23	9.783292	9.900144	9.883148	10.116852	10.099856	10.216708	37
24	9.783458	9.900047	9.883410	10.116590	10.099953	10.216542	36
25	9.783623	9.899951	9.883672	10.116328	10.100049	10.216377	35
26	9.783788	9.899854	9.883934	10.116066	10.100146	10.216212	34
27	9.783953	9.899757	9.884196	10.115804	10.100243	10.216047	33
28	9.784118	9.899660	9.884457	10.115543	10.100340	10.215882	32
29	9.784282	9.899564	9.884719	10.115281	10.100436	10.215718	31
30	9.784447	9.899467	9.884980	10.115020	10.100533	10.215553	30
31	9.784612	9.899370	9.885242	10.114758	10.100630	10.215388	29
32	9.784776	9.899273	9.885503	10.114497	10.100727	10.215224	28
33	9.784941	9.899176	9.885765	10.114235	10.100824	10.215059	27
34	9.785105	9.899078	9.886026	10.113974	10.100922	10.214895	26
35	9.785269	9.898981	9.886288	10.113712	10.101019	10.214731	25
36	9.785433	9.898884	9.886549	10.113451	10.101116	10.214567	24
37	9.785597	9.898787	9.886810	10.113190	10.101213	10.214403	23
38	9.785761	9.898689	9.887072	10.112928	10.101311	10.214239	22
39	9.785925	9.898592	9.887333	10.112667	10.101408	10.214075	21
40	9.786089	9.898494	9.887594	10.112406	10.101506	10.213911	20
41	9.786252	9.898397	9.887855	10.112145	10.101603	10.213748	19
42	9.786416	9.898299	9.888116	10.111884	10.101701	10.213584	18
43	9.786579	9.898202	9.888377	10.111623	10.101798	10.213421	17
44	9.786742	9.898104	9.888639	10.111361	10.101896	10.213258	16
45	9.786906	9.898006	9.888900	10.111100	10.101994	10.213094	15
46	9.787069	9.897908	9.889160	10.110840	10.102092	10.212931	14
47	9.787232	9.897810	9.889421	10.110579	10.102190	10.212768	13
48	9.787395	9.897712	9.889682	10.110318	10.102288	10.212605	12
49	9.787557	9.897614	9.889943	10.110057	10.102386	10.212443	11
50	9.787720	9.897516	9.890204	10.109796	10.102484	10.212280	10
51	9.787883	9.897418	9.890465	10.109535	10.102582	10.212117	9
52	9.788054	9.897320	9.890725	10.109275	10.102680	10.211955	8
53	9.788208	9.897222	9.890986	10.109014	10.102778	10.211792	7
54	9.788370	9.897123	9.891247	10.108753	10.102877	10.211630	6
55	9.788532	9.897025	9.891507	10.108493	10.102975	10.211468	5
56	9.788694	9.896926	9.891768	10.108232	10.103074	10.211306	4
57	9.788856	9.896828	9.892028	10.107972	10.103172	10.211144	3
58	9.789018	9.896729	9.892289	10.107711	10.103271	10.210982	2
59	9.789180	9.896631	9.892549	10.107451	10.103369	10.210828	1
60	9.789342	9.896532	9.892810	10.107190	10.103468	10.210650	0
M	Co-sine.	Sine.	Co-tang	Tang.	Co-sec.	Secant.	M

52 Degrees.

38 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang.	Secant.	Co-sec.	M
0	9.789342	9.896532	9.892810	10.107190	10.103468	10.210658	60
1	9.789504	9.896433	9.893070	10.106930	10.103567	10.210496	59
2	9.789665	9.896335	9.893331	10.106669	10.103665	10.210335	58
3	9.789827	9.896236	9.893591	10.106409	10.103764	10.210173	57
4	9.789988	9.896137	9.893851	10.106149	10.103863	10.210012	56
5	9.790149	9.896038	9.894111	10.105889	10.103962	10.209851	55
6	9.790310	9.895939	9.894371	10.105629	10.104061	10.209690	54
7	9.790471	9.895840	9.894632	10.105368	10.104160	10.209529	53
8	9.790632	9.895741	9.894892	10.105108	10.104259	10.209368	52
9	9.790793	9.895641	9.895152	10.104848	10.104359	10.209207	51
10	9.790954	9.895542	9.895412	10.104588	10.104458	10.209046	50
11	9.791115	9.895443	9.895672	10.104328	10.104557	10.208885	49
12	9.791275	9.895343	9.895932	10.104068	10.104657	10.208725	48
13	9.791436	9.895244	9.896192	10.103808	10.104756	10.208564	47
14	9.791596	9.895145	9.896452	10.103548	10.104855	10.208404	46
15	9.791757	9.895045	9.896712	10.103288	10.104955	10.208243	45
16	9.791917	9.894945	9.896971	10.103029	10.105055	10.208083	44
17	9.792077	9.894846	9.897231	10.102769	10.105154	10.207923	43
18	9.792237	9.894746	9.897491	10.102509	10.105254	10.207763	42
19	9.792397	9.894646	9.897751	10.102249	10.105354	10.207603	41
20	9.792557	9.894546	9.898010	10.101990	10.105454	10.207443	40
21	9.792716	9.894446	9.898270	10.101730	10.105554	10.207284	39
22	9.792876	9.894346	9.898530	10.101470	10.105654	10.207124	38
23	9.793035	9.894246	9.898789	10.101211	10.105754	10.206965	37
24	9.793195	9.894146	9.899049	10.100951	10.105854	10.206805	36
25	9.793354	9.894046	9.899308	10.100692	10.105954	10.206646	35
26	9.793514	9.893946	9.899568	10.100432	10.106054	10.206486	34
27	9.793673	9.893846	9.899827	10.100173	10.106154	10.206327	33
28	9.793832	9.893745	9.900086	10.099914	10.106255	10.206168	32
29	9.793991	9.893645	9.900346	10.099654	10.106355	10.206009	31
30	9.794150	9.893544	9.900605	10.099395	10.106456	10.205850	30
31	9.794308	9.893444	9.900864	10.099136	10.106556	10.205692	29
32	9.794467	9.893343	9.901124	10.098876	10.106657	10.205533	28
33	9.794626	9.893243	9.901383	10.098617	10.106757	10.205374	27
34	9.794784	9.893142	9.901642	10.098358	10.106858	10.205216	26
35	9.794942	9.893041	9.901901	10.098099	10.106959	10.205058	25
36	9.795101	9.892940	9.902160	10.097840	10.107060	10.204899	24
37	9.795259	9.892839	9.902419	10.097581	10.107161	10.204741	23
38	9.795417	9.892739	9.902679	10.097321	10.107261	10.204583	22
39	9.795575	9.892638	9.902938	10.097062	10.107362	10.204425	21
40	9.795733	9.892536	9.903197	10.096803	10.107464	10.204267	20
41	9.795891	9.892435	9.903455	10.096545	10.107565	10.204109	19
42	9.796049	9.892334	9.903714	10.096286	10.107666	10.203951	18
43	9.796206	9.892233	9.903973	10.096027	10.107767	10.203794	17
44	9.796364	9.892132	9.904232	10.095768	10.107868	10.203636	16
45	9.796521	9.892030	9.994491	10.095509	10.107970	10.203479	15
46	9.796679	9.891929	9.904750	10.095250	10.108071	10.203321	14
47	9.796836	9.891827	9.905008	10.094992	10.108173	10.203164	13
48	9.796993	9.891726	9.905267	10.094733	10.108274	10.203007	12
49	9.797150	9.891624	9.905526	10.094474	10.108376	10.202850	11
50	9.797307	9.891523	9.905784	10.094216	10.108477	10.202693	10
51	9.797464	9.891421	9.906043	10.093957	10.108579	10.202536	9
52	9.797621	9.891319	9.906302	10.093698	10.108681	10.202379	8
53	9.797777	9.891217	9.906560	10.093440	10.108783	10.202223	7
54	9.797934	9.891115	9.906819	10.093181	10.108885	10.202066	6
55	9.798091	9.891013	9.907077	10.092923	10.108987	10.201909	5
56	9.798247	9.890911	9.907336	10.092664	10.109089	10.201753	4
57	9.798403	9.890809	9.907594	10.092406	10.109191	10.201597	3
58	9.798560	9.890707	9.907852	10.092148	10.109293	10.201440	2
59	9.798716	9.890605	9.908111	10.091889	10.109395	10.201284	1
60	9.798872	9.890503	9.908369	10.091631	10.109497	10.201128	0
M	Co-sine.	Sine.	Co-tang.	Tang.	Co-sec.	Secant.	M

51 Degrees.

39 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang.	Secant	Co-sec.	M
0	9.798872	9.890503	9.908369	10.091631	10.109497	10.201128	60
1	9.799028	9.890400	9.908628	10.091372	10.109600	10.200972	59
2	9.799184	9.890298	9.908886	10.091114	10.109702	10.200816	58
3	9.799339	9.890195	9.909144	10.090856	10.109805	10.200661	57
4	9.799495	9.890093	9.909402	10.090598	10.109907	10.200505	56
5	9.799651	9.889990	9.909660	10.090340	10.110010	10.200349	55
6	9.799806	9.889888	9.909918	10.090082	10.110112	10.200194	54
7	9.799962	9.889785	9.910177	10.089823	10.110215	10.200038	53
8	9.800117	9.889682	9.910435	10.089565	10.110318	10.199883	52
9	9.800272	9.889579	9.910693	10.089307	10.110421	10.199728	51
10	9.800427	9.889477	9.910951	10.089049	10.110523	10.199573	50
11	9.800582	9.889374	9.911209	10.088791	10.110626	10.199418	49
12	9.800737	9.889271	9.911467	10.088533	10.110729	10.199263	48
13	9.800892	9.889168	9.911724	10.088276	10.110832	10.199108	47
14	9.801047	9.889064	9.911982	10.088018	10.110936	10.198953	46
15	9.801201	9.888961	9.912240	10.087760	10.111039	10.198799	45
16	9.801356	9.888858	9.912498	10.087502	10.111142	10.198644	44
17	9.801511	9.888755	9.912756	10.087244	10.111245	10.198489	43
18	9.801665	9.888651	9.913014	10.086986	10.111349	10.198335	42
19	9.801819	9.888548	9.913271	10.086729	10.111452	10.198181	41
20	9.801973	9.888444	9.913529	10.086471	10.111556	10.198027	40
21	9.802128	9.888341	9.913787	10.086213	10.111659	10.197872	39
22	9.802282	9.888237	9.914044	10.085956	10.111763	10.197718	38
23	9.802436	9.888134	9.914302	10.085698	10.111866	10.197564	37
24	9.802589	9.888030	9.914560	10.085440	10.111970	10.197411	36
25	9.802743	9.887926	9.914817	10.085183	10.112074	10.197257	35
26	9.802897	9.887822	9.915075	10.084925	10.112178	10.197103	34
27	9.803050	9.887718	9.915332	10.084668	10.112282	10.196950	33
28	9.803204	9.887614	9.915590	10.084410	10.112386	10.196796	32
29	9.803357	9.887510	9.915847	10.084153	10.112490	10.196643	31
30	9.803511	9.887406	9.916104	10.083896	10.112594	10.196489	30
31	9.803664	9.887302	9.916362	10.083638	10.112698	10.196336	29
32	9.803817	9.887198	9.916619	10.083381	10.112802	10.196183	28
33	9.803970	9.887093	9.916877	10.083123	10.112907	10.196030	27
34	9.804123	9.886989	9.917134	10.082866	10.113011	10.195877	26
35	9.804276	9.886885	9.917391	10.082609	10.113115	10.195724	25
36	9.804428	9.886780	9.917648	10.082352	10.113220	10.195572	24
37	9.804581	9.886676	9.917905	10.082095	10.113324	10.195419	23
38	9.804734	9.886571	9.918163	10.081837	10.113429	10.195266	22
39	9.804886	9.886466	9.918420	10.081580	10.113534	10.195114	21
40	9.805039	9.886362	9.918677	10.081323	10.113638	10.194961	20
41	9.805191	9.886257	9.918934	10.081066	10.113743	10.194809	19
42	9.805343	9.886152	9.919191	10.080809	10.113848	10.194657	18
43	9.805495	9.886047	9.919448	10.080552	10.113953	10.194505	17
44	9.805647	9.885942	9.919705	10.080295	10.114058	10.194353	16
45	9.805799	9.885837	9.919962	10.080038	10.114163	10.194201	15
46	9.805951	9.885732	9.920219	10.079781	10.114268	10.194049	14
47	9.806103	9.885627	9.920476	10.079524	10.114373	10.193897	13
48	9.806254	9.885522	9.920733	10.079267	10.114478	10.193746	12
49	9.806406	9.885416	9.920990	10.079010	10.114584	10.193594	11
50	9.806557	9.885311	9.921247	10.078753	10.114689	10.193443	10
51	9.806709	9.885205	9.921503	10.078497	10.114795	10.193291	9
52	9.806860	9.885100	9.921760	10.078240	10.114900	10.193140	8
53	9.807011	9.884994	9.922017	10.077983	10.115006	10.192989	7
54	9.807163	9.884889	9.922274	10.077726	10.115111	10.192837	6
55	9.807314	9.884783	9.922530	10.077470	10.115217	10.192686	5
56	9.807465	9.884677	9.922787	10.077213	10.115323	10.192535	4
57	9.807615	9.884572	9.923044	10.076956	10.115428	10.192385	3
58	9.807766	9.884466	9.923300	10.076700	10.115534	10.192234	2
59	9.807917	9.884360	9.923557	10.076443	10.115640	10.192083	1
60	9.808067	9.884254	9.923813	10.076187	10.115746	10.191933	0
M	Co-sine.	Sine.	Co-tang.	Tang.	Co-sec.	Secant.	M

50 Degrees.

40 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang.	Secant.	Co-sec.	M
0	9.808067	9.884254	9.923813	10.076187	10.115746	10.191933	60
1	9.808218	9.884148	9.924070	10.075930	10.115852	10.191782	59
2	9.808368	9.884042	9.924327	10.075673	10.115958	10.191632	58
3	9.808519	9.883936	9.924583	10.075417	10.116064	10.191481	57
4	9.808669	9.883829	9.924840	10.075160	10.116171	10.191331	56
5	9.808819	9.883723	9.925096	10.074904	10.116277	10.191181	55
6	9.808969	9.883617	9.925352	10.074648	10.116383	10.191031	54
7	9.809119	9.883510	9.925609	10.074391	10.116490	10.190881	53
8	9.809269	9.883404	9.925865	10.074135	10.116596	10.190731	52
9	9.809419	9.883297	9.926122	10.073878	10.116703	10.190581	51
10	9.809569	9.883191	9.926378	10.073622	10.116809	10.190431	50
11	9.809718	9.883084	9.926634	10.073366	10.116916	10.190282	49
12	9.809868	9.882977	9.926890	10.073110	10.117023	10.190132	48
13	9.810017	9.882871	9.927147	10.072853	10.117129	10.189983	47
14	9.810167	9.882764	9.927403	10.072597	10.117236	10.189833	46
15	9.810316	9.882657	9.927659	10.072341	10.117343	10.189684	45
16	9.810465	9.882550	9.927915	10.072085	10.117450	10.189535	44
17	9.810614	9.882443	9.928171	10.071829	10.117557	10.189386	43
18	9.810763	9.882336	9.928427	10.071573	10.117664	10.189237	42
19	9.810912	9.882229	9.928683	10.071317	10.117771	10.189088	41
20	9.811061	9.882121	9.928940	10.071060	10.117879	10.188939	40
21	9.811210	9.882014	9.929196	10.070804	10.117986	10.188790	39
22	9.811358	9.881907	9.929452	10.070548	10.118093	10.188642	38
23	9.811507	9.881799	9.929708	10.070292	10.118201	10.188493	37
24	9.811655	9.881692	9.929964	10.070036	10.118308	10.188345	36
25	9.811804	9.881584	9.930220	10.069780	10.118416	10.188196	35
26	9.811952	9.881477	9.930475	10.069525	10.118523	10.188048	34
27	9.812100	9.881369	9.930731	10.069269	10.118631	10.187900	33
28	9.812248	9.881261	9.930987	10.069013	10.118739	10.187752	32
29	9.812396	9.881153	9.931243	10.068757	10.118847	10.187604	31
30	9.812544	9.881046	9.931499	10.068501	10.118954	10.187456	30
31	9.812692	9.880938	9.931755	10.068245	10.119062	10.187308	29
32	9.812840	9.880830	9.932010	10.067990	10.119170	10.187160	28
33	9.812988	9.880722	9.932266	10.067734	10.119278	10.187012	27
34	9.813135	9.880613	9.932522	10.067478	10.119387	10.186865	26
35	9.813283	9.880505	9.932778	10.067222	10.119495	10.186717	25
36	9.813430	9.880397	9.933033	10.066967	10.119603	10.186570	24
37	9.813578	9.880289	9.933289	10.066711	10.119711	10.186422	23
38	9.813725	9.880180	9.933545	10.066455	10.119820	10.186275	22
39	9.813872	9.880072	9.933800	10.066200	10.119928	10.186128	21
40	9.814019	9.879963	9.934056	10.065944	10.120037	10.185981	20
41	9.814166	9.879855	9.934311	10.065689	10.120145	10.185834	19
42	9.814313	9.879746	9.934567	10.065433	10.120254	10.185687	18
43	9.814460	9.879637	9.934823	10.065177	10.120363	10.185540	17
44	9.814607	9.879529	9.935078	10.064922	10.120471	10.185393	16
45	9.814753	9.879420	9.935333	10.064667	10.120580	10.185247	15
46	9.814900	9.879311	9.935589	10.064411	10.120689	10.185100	14
47	9.815046	9.879202	9.935844	10.064156	10.120798	10.184954	13
48	9.815193	9.879093	9.936100	10.063900	10.120907	10.184807	12
49	9.815339	9.878984	9.936355	10.063645	10.121016	10.184661	11
50	9.815485	9.878875	9.936610	10.063390	10.121125	10.184515	10
51	9.815632	9.878766	9.936866	10.063134	10.121234	10.184368	9
52	9.815778	9.878656	9.937121	10.062879	10.121344	10.184222	8
53	9.815924	9.878547	9.937376	10.062624	10.121453	10.184076	7
54	9.816069	9.878438	9.937632	10.062368	10.121562	10.183931	6
55	9.816215	9.878328	9.937887	10.062113	10.121672	10.183785	5
56	9.816361	9.878219	9.938142	10.061858	10.121781	10.183639	4
57	9.816507	9.878109	9.938398	10.061602	10.121891	10.183493	3
58	9.816652	9.877999	9.938653	10.061347	10.122001	10.183348	2
59	9.816798	9.877890	9.938908	10.061092	10.122110	10.183202	1
60	9.816943	9.877780	9.939163	10.060837	10.122220	10.183057	0
M	Co-sine.	Sine.	Co-tang.	Tang.	Co-sec.	Secant.	M

49 Degrees.

41 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang.	Secant.	Co-sec.	M
0	9.816943	9.877780	9.939163	10.060837	10.122220	10.183057	60
1	9.817088	9.877670	9.939418	10.060582	10.122330	10.182912	59
2	9.817233	9.877560	9.939673	10.060327	10.122440	10.182767	58
3	9.817379	9.877450	9.939928	10.060072	10.122550	10.182621	57
4	9.817524	9.877340	9.940183	10.059817	10.122660	10.182476	56
5	9.817668	9.877230	9.940438	10.059562	10.122770	10.182332	55
6	9.817813	9.877120	9.940694	10.059306	10.122880	10.182187	54
7	9.817958	9.877010	9.940949	10.059051	10.122990	10.182042	53
8	9.818103	9.876899	9.941204	10.058796	10.123101	10.181897	52
9	9.818247	9.876789	9.941458	10.058542	10.123211	10.181753	51
10	9.818392	9.876678	9.941714	10.058286	10.123322	10.181608	50
11	9.818536	9.876568	9.941968	10.058032	10.123432	10.181464	49
12	9.818681	9.876457	9.942223	10.057777	10.123543	10.181319	48
13	9.818825	9.876347	9.942478	10.057522	10.123653	10.181175	47
14	9.818969	9.876236	9.942733	10.057267	10.123764	10.181031	46
15	9.819113	9.876125	9.942988	10.057012	10.123875	10.180887	45
16	9.819257	9.876014	9.943243	10.056757	10.123986	10.180743	44
17	9.819401	9.875904	9.943498	10.056502	10.124096	10.180599	43
18	9.819545	9.875793	9.943752	10.056248	10.124207	10.180455	42
19	9.819689	9.875682	9.944007	10.055993	10.124318	10.180311	41
20	9.819832	9.875571	9.944262	10.055738	10.124429	10.180168	40
21	9.819976	9.875459	9.944517	10.055483	10.124541	10.180024	39
22	9.820120	9.875348	9.944771	10.055229	10.124652	10.179880	38
23	9.820263	9.875237	9.945026	10.054974	10.124763	10.179737	37
24	9.820406	9.875126	9.945281	10.054719	10.124874	10.179594	36
25	9.820550	9.875014	9.945535	10.054465	10.124986	10.179450	35
26	9.820693	9.874903	9.945790	10.054210	10.125097	10.179307	34
27	9.820836	9.874791	9.946045	10.053955	10.125209	10.179164	33
28	9.820979	9.874680	9.946299	10.053701	10.125320	10.179021	32
29	9.821122	9.874568	9.946554	10.053446	10.125432	10.178878	31
30	9.821265	9.874456	9.946808	10.053192	10.125544	10.178735	30
31	9.821407	9.874344	9.947063	10.052937	10.125656	10.178593	29
32	9.821550	9.874232	9.947318	10.052682	10.125768	10.178450	28
33	9.821693	9.874121	9.947572	10.052428	10.125879	10.178307	27
34	9.821835	9.874009	9.947826	10.052174	10.125991	10.178165	26
35	9.821977	9.873896	9.948081	10.051919	10.126104	10.178023	25
36	9.822120	9.873784	9.948336	10.051664	10.126216	10.177880	24
37	9.822262	9.873672	9.948590	10.051410	10.126328	10.177738	23
38	9.822404	9.873560	9.948844	10.051156	10.126440	10.177596	22
39	9.822546	9.873448	9.949099	10.050901	10.126552	10.177454	21
40	9.822688	9.873335	9.949353	10.050647	10.126665	10.177312	20
41	9.822830	9.873223	9.949607	10.050393	10.126777	10.177170	19
42	9.822972	9.873110	9.949862	10.050138	10.126890	10.177028	18
43	9.823114	9.872998	9.950116	10.049884	10.127002	10.176886	17
44	9.823255	9.872885	9.950370	10.049630	10.127115	10.176745	16
45	9.823397	9.872772	9.950625	10.049375	10.127228	10.176603	15
46	9.823539	9.872659	9.950879	10.049121	10.127341	10.176461	14
47	9.823680	9.872547	9.951133	10.048867	10.127453	10.176320	13
48	9.823821	9.872434	9.951388	10.048612	10.127566	10.176179	12
49	9.823963	9.872321	9.951642	10.048358	10.127679	10.176037	11
50	9.824104	9.872208	9.951896	10.048104	10.127792	10.175896	10
51	9.824245	9.872095	9.952150	10.047850	10.127905	10.175755	9
52	9.824386	9.871981	9.952405	10.047595	10.128019	10.175614	8
53	9.824527	9.871868	9.952659	10.047341	10.128132	10.175473	7
54	9.824668	9.871755	9.952913	10.047087	10.128245	10.175332	6
55	9.824808	9.871641	9.953167	10.046833	10.128359	10.175192	5
56	9.824949	9.871528	9.953421	10.046579	10.128472	10.175051	4
57	9.825090	9.871414	9.953675	10.046325	10.128586	10.174910	3
58	9.825230	9.871301	9.953929	10.046071	10.128699	10.174770	2
59	9.825371	9.871187	9.954183	10.045817	10.128813	10.174629	1
60	9.825511	9.871073	9.954437	10.045563	10.128927	10.174489	0
M	Co-sine.	Sine.	Co-tang.	Tang.	Co-sec.	Secant.	M

48 Degrees,

42 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang	Secant.	Co-sec	M
0	9.825511	9.871073	9.954437	10.045563	10.128927	10.174489	60
1	9.825651	9.870960	9.954691	10.045309	10.129040	10.174349	59
2	9.825791	9.870846	9.954945	10.045055	10.129154	10.174209	58
3	9.825931	9.870732	9.955200	10.044800	10.129268	10.174069	57
4	9.826071	9.870618	9.955454	10.044546	10.129382	10.173929	56
5	9.826211	9.870504	9.955707	10.044293	10.129496	10.173789	55
6	9.826351	9.870390	9.955961	10.044039	10.129610	10.173649	54
7	9.826491	9.870276	9.956215	10.043785	10.129724	10.173509	53
8	9.826631	9.870161	9.956469	10.043531	10.129839	10.173369	52
9	9.826770	9.870047	9.956723	10.043277	10.129953	10.173230	51
10	9.826910	9.869933	9.956977	10.043023	10.130067	10.173090	50
11	9.827049	9.869818	9.957231	10.042769	10.130182	10.172951	49
12	9.827189	9.869704	9.957485	10.042515	10.130296	10.172811	48
13	9.827328	9.869589	9.957739	10.042261	10.130411	10.172672	47
14	9.827467	9.869474	9.957993	10.042007	10.130526	10.172533	46
15	9.827606	9.869360	9.958246	10.041754	10.130640	10.172394	45
16	9.827745	9.869245	9.958500	10.041500	10.130755	10.172255	44
17	9.827884	9.869130	9.958754	10.041246	10.130870	10.172116	43
18	9.828023	9.869015	9.959008	10.040992	10.130985	10.171977	42
19	9.828162	9.868900	9.959262	10.040738	10.131100	10.171838	41
20	9.828301	9.868785	9.959516	1.0040484	10.131215	10.171699	40
21	9.828439	9.868670	9.959769	10.040231	10.131330	10.171561	39
22	9.828578	9.868555	9.960023	10.039977	10.131445	10.171422	38
23	9.828716	9.868440	9.960277	10.039723	10.131560	10.171284	37
24	9.828855	9.868324	9.960531	10.039469	10.131676	10.171145	36
25	9.828993	9.868209	9.960784	10.039216	10.131791	10.171007	35
26	9.829131	9.868093	9.961038	10.038962	10.131907	10.170869	34
27	9.829269	9.867978	9.961291	10.038709	10.132022	10.170731	33
28	9.829407	9.867862	9.961545	10.038455	10.132138	10.170593	32
29	9.829545	9.867747	9.961799	10.038201	10.132253	10.170455	31
30	9.829683	9.867631	9.962052	10.037948	10.132369	10.170317	30
31	9.829821	9.867515	9.962306	10.037694	10.132485	10.170179	29
32	9.829959	9.867399	9.962560	10.037440	10.132601	10.170041	28
33	9.830097	9.867283	9.962813	10.037187	10.132717	10.169903	27
34	9.830234	9.867167	9.963067	10.036933	10.132833	10.169766	26
35	9.830372	9.867051	9.963320	10.036680	10.132949	10.169628	25
36	9.830509	9.866935	9.963574	10.036426	10.133065	10.169491	24
37	9.830646	9.866819	9.963827	10.036173	10.133181	10.169354	23
38	9.830784	9.866703	9.964081	10.035919	10.133297	10.169216	22
39	9.830921	9.866586	9.964335	10.035665	10.133414	10.169079	21
40	9.831058	9.866470	9.964588	10.035412	10.133530	10.168942	20
41	9.831195	9.866353	9.964842	10.035158	10.133647	10.168805	19
42	9.831332	9.866237	9.965095	10.034905	10.133763	10.168668	18
43	9.831469	9.866120	9.965349	10.034651	10.133880	10.168531	17
44	9.831606	9.866004	9.965602	10.034398	10.133996	10.168394	16
45	9.831742	9.865887	9.965855	10.034145	10.134113	10.168258	15
46	9.831879	9.865770	9.966109	10.033891	10.134230	10.168121	14
47	9.832015	9.865653	9.966362	10.033638	10.134347	10.167985	13
48	9.832152	9.865536	9.966616	10.033384	10.134464	10.167848	12
49	9.832288	9.865419	9.966869	10.033131	10.134581	10.167712	11
50	9.832425	9.865302	9.967123	10.032877	10.134698	10.167575	10
51	9.832561	9.865185	9.967376	10.032624	10.134815	10.167439	9
52	9.832697	9.865068	9.967629	10.032371	10.134932	10.167303	8
53	9.832833	9.864950	9.967883	10.032117	10.135050	10.167167	7
54	9.832969	9.864833	9.968136	10.031864	10.135167	10.167031	6
55	9.833105	9.864716	9.968389	10.031611	10.135284	10.166895	5
56	9.833241	9.864598	9.968643	10.031357	10.135402	10.166759	4
57	9.833377	9.864481	9.968896	10.031104	10.135519	10.166623	3
58	9.833512	9.864363	9.969149	10.030851	10.135637	10.166488	2
59	9.833648	9.864245	9.969403	10.030597	10.135755	10.166352	1
60	9.833783	9.864127	9.969656	10.030344	10.135873	10.166217	0
M	Co-sine	Sine.	Co-tang.	Tang.	Co sec.	Secant	M

47 Degrees.

43 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang.	Secant.	Co-sec.	M
0	9.833783	9.864127	9.969656	10.030344	10.135873	10.166217	60
1	9.833919	9.864010	9.969909	10.030091	10.135990	10.166081	59
2	9.834054	9.863892	9.970162	10.029838	10.136108	10.165946	58
3	9.834189	9.863774	9.970416	10.029584	10.136226	10.165811	57
4	9.834325	9.863656	9.970669	10.029331	10.136344	10.165675	56
5	9.834460	9.863538	9.970922	10.029078	10.136462	10.165540	55
6	9.834595	9.863419	9.971175	10.028825	10.136581	10.165405	54
7	9.834730	9.863301	9.971429	10.028571	10.136699	10.165270	53
8	9.834865	9.863183	9.971682	10.028318	10.136817	10.165135	52
9	9.834999	9.863064	9.971935	10.028065	10.136936	10.165001	51
10	9.835134	9.862946	9.972188	10.027812	10.137054	10.164866	50
11	9.835269	9.862827	9.972441	10.027559	10.137172	10.164731	49
12	9.835403	9.862709	9.972694	10.027306	10.137291	10.164597	48
13	9.835538	9.862590	9.972948	10.027052	10.137410	10.164462	47
14	9.835672	9.862471	9.973201	10.026799	10.137529	10.164328	46
15	9.835807	9.862353	9.973454	10.026546	10.137647	10.164193	45
16	9.835941	9.862234	9.973707	10.026293	10.137766	10.164059	44
17	9.836075	9.862115	9.973960	10.026040	10.137885	10.163925	43
18	9.836209	9.861996	9.974213	10.025787	10.138004	10.163791	42
19	9.836343	9.861877	9.974466	10.025534	10.138123	10.163657	41
20	9.836477	9.861758	9.974719	10.025281	10.138242	10.163523	40
21	9.836611	9.861638	9.974973	10.025027	10.138362	10.163389	39
22	9.836745	9.861519	9.975226	10.024774	10.138481	10.163255	38
23	9.836878	9.861400	9.975479	10.024521	10.138600	10.163122	37
24	9.837012	9.861280	9.975732	10.024268	10.138720	10.162988	36
25	9.837146	9.861161	9.975985	10.024015	10.138839	10.162854	35
26	9.837279	9.861041	9.976238	10.023762	10.138959	10.162721	34
27	9.837412	9.860922	9.976491	10.023509	10.139078	10.162588	33
28	9.837546	9.860802	9.976744	10.023256	10.139198	10.162454	32
29	9.837679	9.860682	9.976997	10.023003	10.139318	10.162321	31
30	9.837812	9.860562	9.977250	10.022750	10.139438	10.162188	30
31	9.837945	9.860442	9.977503	10.022497	10.139558	10.162055	29
32	9.838078	9.860322	9.977756	10.022244	10.139678	10.161922	28
33	9.838211	9.860202	9.978009	10.021991	10.139798	10.161789	27
34	9.838344	9.860082	9.978262	10.021738	10.139918	10.161656	26
35	9.838477	9.859962	9.978515	10.021485	10.140038	10.161523	25
36	9.838610	9.859842	9.978768	10.021232	10.140158	10.161390	24
37	9.838742	9.859721	9.979021	10.020979	10.140279	10.161258	23
38	9.838875	9.859601	9.979274	10.020726	10.140399	10.161125	22
39	9.839007	9.859480	9.979527	10.020473	10.140520	10.160993	21
40	9.839140	9.859360	9.979780	10.020220	10.140640	10.160860	20
41	9.839272	9.859239	9.980033	10.019967	10.140761	10.160728	19
42	9.839404	9.859119	9.980286	10.019714	10.140881	10.160596	18
43	9.839536	9.858998	9.980538	10.019462	10.141002	10.160464	17
44	9.839668	9.858877	9.980791	10.019209	10.141123	10.160332	16
45	9.839800	9.858756	9.981044	10.018956	10.141244	10.160200	15
46	9.839932	9.858635	9.981297	10.018703	10.141365	10.160068	14
47	9.840064	9.858514	9.981550	10.018450	10.141486	10.159936	13
48	9.840196	9.858393	9.981803	10.018197	10.141607	10.159804	12
49	9.840328	9.858272	9.982056	10.017944	10.141728	10.159672	11
50	9.840459	9.858157	9.982309	10.017691	10.141849	10.159541	10
51	9.840591	9.858029	9.982562	10.017438	10.141971	10.159409	9
52	9.840722	9.857908	9.982814	10.017186	10.142092	10.159278	8
53	9.840854	9.857786	9.983067	10.016933	10.142214	10.159146	7
54	9.840985	9.857665	9.983320	10.016680	10.142335	10.159015	6
55	9.841116	9.857543	9.983573	10.016427	10.142457	10.158884	5
56	9.841247	9.857422	9.983826	10.016174	10.142578	10.158753	4
57	9.841378	9.857300	9.984079	10.015921	10.142700	10.158622	3
58	9.841509	9.857178	9.984331	10.015669	10.142822	10.158491	2
59	9.841640	9.857056	9.984584	10.015416	10.142944	10.158360	1
60	9.841771	9.856934	9.984837	10.015163	10.143066	10.158229	0
M	Co-sine.	Sine.	Co-tang.	Tang.	Co-sec.	Secant.	M

46 Degrees.

44 Degrees.

M	Sine.	Co-sine.	Tang.	Co-tang.	Secant.	Co-sec	M
0	9.841771	9.856934	9.984837	10.015163	10.143066	10.158229	60
1	9.841902	9.856812	9.985090	10.014910	10.143188	10.158098	59
2	9.842033	9.856690	9.985343	10.014657	10.143310	10.157967	58
3	9.842163	9.856568	9.985596	10.014404	10.143432	10.157837	57
4	9.842294	9.856446	9.985848	10.014152	10.143554	10.157706	56
5	9.842424	9.856323	9.986101	10.013899	10.143677	10.157576	55
6	9.842555	9.856201	9.986354	10.013646	10.143799	10.157445	54
7	9.842685	9.856078	9.986607	10.013393	10.143922	10.157315	53
8	9.842815	9.855956	9.986860	10.013140	10.144044	10.157185	52
9	9.842946	9.855833	9.987112	10.012888	10.144167	10.157054	51
10	9.843076	9.855711	9.987365	10.012635	10.144289	10.156924	50
11	9.843206	9.855588	9.987618	10.012382	10.144412	10.156794	49
12	9.843336	9.855465	9.987871	10.012129	10.144535	10.156664	48
13	9.843466	9.855342	9.988123	10.011877	10.144658	10.156534	47
14	9.843595	9.855219	9.988376	10.011624	10.144781	10.156405	46
15	9.843725	9.855096	9.988629	10.011371	10.144904	10.156275	45
16	9.843855	9.854973	9.988882	10.011118	10.145027	10.156145	44
17	9.843984	9.854850	9.989134	10.010866	10.145150	10.156016	43
18	9.844114	9.854727	9.989387	10.010613	10.145273	10.155886	42
19	9.844243	9.854603	9.989640	10.010360	10.145397	10.155757	41
20	9.844372	9.854480	9.989893	10.010107	10.145520	10.155628	40
21	9.844502	9.854356	9.990145	10.009855	10.145644	10.155498	39
22	9.844631	9.854233	9.990398	10.009602	10.145767	10.155369	38
23	9.844760	9.854109	9.990651	10.009349	10.145891	10.155240	37
24	9.844889	9.853986	9.990903	10.009097	10.146014	10.155111	36
25	9.845018	9.853862	9.991156	10.008844	10.146138	10.154982	35
26	9.845147	9.853738	9.991409	10.008591	10.146262	10.154853	34
27	9.845276	9.853614	9.991662	10.008338	10.146386	10.154724	33
28	9.845405	9.853490	9.991914	10.008086	10.146510	10.154595	32
29	9.845533	9.853366	9.992167	10.007833	10.146634	10.154467	31
30	9.845662	9.853242	9.992420	10.007580	10.146758	10.154338	30
31	9.845790	9.853118	9.992672	10.007328	10.146882	10.154210	29
32	9.845919	9.852994	9.992925	10.007075	10.147006	10.154081	28
33	9.846047	9.852869	9.993178	10.006822	10.147131	10.153953	27
34	9.846175	9.852745	9.993430	10.006570	10.147255	10.153825	26
35	9.846304	9.852620	9.993683	10.006317	10.147380	10.153696	25
36	9.846432	9.852496	9.993936	10.006064	10.147504	10.153568	24
37	9.846560	9.852371	9.994189	10.005811	10.147629	10.153440	23
38	9.846688	9.852247	9.994441	10.005559	10.147753	10.153312	22
39	9.846816	9.852122	9.994694	10.005306	10.147878	10.153184	21
40	9.846944	9.854997	9.994947	10.005053	10.148003	10.153056	20
41	9.847071	9.851872	9.995199	10.004801	10.148128	10.152929	19
42	9.847199	9.851747	9.995452	10.004548	10.148253	10.152801	18
43	9.847327	9.851622	9.995705	10.004295	10.148378	10.152673	17
44	9.847454	9.851497	9.995957	10.004043	10.148503	10.152546	16
45	9.847582	9.851372	9.996210	10.003790	10.148623	10.152418	15
46	9.847709	9.851246	9.996463	10.003537	10.148754	10.152291	14
47	9.847836	9.851121	9.996715	10.003285	10.148879	10.152164	13
48	9.847964	9.850996	9.996968	10.003032	10.149004	10.152036	12
49	9.848091	9.850870	9.997221	10.002779	10.149130	10.151909	11
50	9.848218	9.850745	9.997473	10.002527	10.149255	10.151782	10
51	9.848345	9.850619	9.997726	10.002274	10.149381	10.151655	9
52	9.848472	9.850493	9.997979	10.002021	10.149507	10.151528	8
53	9.848599	9.850368	9.998231	10.001769	10.149632	10.151401	7
54	9.848726	9.850242	9.998484	10.001516	10.149758	10.151274	6
55	9.848852	9.850116	9.998737	10.001263	10.149884	10.151148	5
56	9.848979	9.849990	9.998989	10.001011	10.150010	10.151021	4
57	9.849106	9.849864	9.999242	10.000758	10.150136	10.150894	3
58	9.849232	9.849738	9.999495	10.000505	10.150262	10.150768	2
59	9.849359	9.849611	9.999747	10.000253	10.150389	10.150641	1
60	9.849485	9.849485	10.000000	10.000000	10.150515	10.150515	0
M	Co-sine.	Sine.	Co-tang.	Tang.	Co-sec.	Secant.	M

45 Degrees.

TABLE. III.

Natural Sines.

In this table the natural sines are exhibited to every degree and minute of the quadrant, and arranged so that the degrees corresponding to the sines are to be taken from the top of the page with their minutes in the left side columns, and the degrees answering to the co-sines from the bottom with their minutes in the right side columns.

The natural sine or co-sine of any number of degrees, &c. more than 90, is the same as the natural sine or co-sine of its supplement, found by subtracting them from 180°; or the natural sine or co-sine of an arch greater than 90° is the natural co-sine or sine of its excess above 90°.

To find the natural Sine or Co-sine of a given Number of Degrees, Minutes, and Seconds:

Or, to find the degrees, Minutes, and Seconds, corresponding to a given natural Sine or Co-sine.

These are to be found as directed for the logarithmic sines, &c. except that the differences to 100″ are to be taken from the bottom of that column containing the given degrees in the former case, or the nearest natural sine or co-sine in the latter.

EXAMPLE I.

Required the natural Sine of 32° 21′ 45″, or its Supplement 147° 38′ 15″.

The natural sine of 32° 21′ is - - - - - -	535090
The difference at the bottom of the column containing the natural sine of the given degrees and minutes is 409, this multiplied by 45, pointing off two figures in the product, is - - - - - - - - -	+ 184
Sum is the natural sine required - - - - -	535274

EXAMPLE II.

Required the natural Co-sine of 71° 40′ 25″, or 108° 19′ 35″.

The natural co-sine of 71° 40′ is - - - - - -	314545
The difference 460, multiplied by 25, pointing off two figures, is	—115
Remainder is the natural co-sine required - - -	314430

EXAMPLE III.

Required the Degrees, Minutes, and Seconds, answering to the natural Sine 495994.

The natural sine next less to that given is 495964, answering to 29° 44′; the difference between this natural sine and the given one is 30, to which two cyphers being added, and that divided by 422, the difference at the bottom of the column, gives the quotient 7″ to be annexed to 29° 44′. Hence 29′ 44′ 7″, or its supplement 150° 15′ 53″, are the degrees, &c. required.

EXAMPLE IV.

Required the degrees, Minutes, and Seconds, answering to the natural Co-sine 368805.

The natural Co-sine next greater to that given is 368936, to which answers 68° 21′; the difference between this natural sine and the given one is 131, to which two cyphers being added, and that divided by 451, the difference found at the bottom of the column, gives the quotient 29″. Hence 68° 21′ 29″, or its supplement, 111° 38′ 31″ are the degrees, &c. required.

To find the natural versed Sine of a given Number of Degrees, Minutes, and Seconds.

If the given arch be less than 90°, find its natural co-sine, which subtract from 1000000, and the remainder will be the natural versed sine required. But if the given arch exceed 90°, find the natural co-sine of its supplement, which add to 1000000, and the sum will be the natural versed sine required.

EXAMPLE I.

Required the natural versed Sine of 20° 39′.

The natural co-sine of 20° 39′ is 935752, which subtracted from 1000000, leaves 064248, the natural versed sine of 20° 39′.

EXAMPLE II.

Required the natural versed Sine of 146° 38′ 40.″

The natural co-sine of 33° 21′ 20″ (the supplement of 146° 38′ 40″) is 835274, which added to 1000000, the sum 1835274 is the natural versed sine required.

To find the Degrees, &c. corresponding to a given natural versed Sine.

Take the difference between the given natural versed sine and 1000000, and the remainder will be a natural co-sine; the degrees, &c. corresponding to which, will be those required, if the given natural versed sine be less than 1000000, but if otherwise, it will be their supplement.

EXAMPLE I.

Required the Degrees, &c. answering to the natural versed sine 098965.

The above subtracted from 1000000, leaves 901035, which taken as a natural co-sine, corresponds to 25° 42′ 20″.

EXAMPLE II.

Required the Degrees, &c. answering to the natural versed Sine 1160172.

Here 1000000 subtracted from the above, leaves 160172, which taken out as a natural co-sine, corresponds to 80° 46′ 59″; therefore its supplement 99° 13′ 1″ are the degrees, &c. required.

M	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	M
0	000000	017452	034899	052336	069756	087156	104528	121869	139173	156434	60
1	000291	017743	035190	052626	070047	087446	104818	122158	139461	156722	59
2	000582	018034	035481	052917	070337	087735	105107	122447	139749	157009	58
3	000873	018325	035772	053207	070627	088025	105396	122735	140037	157296	57
4	001164	018616	036062	053498	070917	088315	105686	123024	140325	157584	56
5	001454	018907	036353	053788	071207	088605	105975	123313	140613	157871	55
6	001745	019197	036644	054079	071497	088894	106264	123601	140901	158158	54
7	002036	019488	036934	054369	071788	089184	106553	123890	141189	158445	53
8	002327	019779	037225	054660	072078	089474	106843	124179	141477	158732	52
9	002618	020070	037516	054950	072368	089763	107132	124467	141765	159020	51
10	002909	020361	037806	055241	072658	090053	107421	124756	142053	159307	50
11	003200	020652	038097	055531	072948	090343	107710	125045	142341	159594	49
12	003491	020942	038388	055822	073238	090633	107999	125333	142629	159881	48
13	003782	021233	038678	056112	073528	090922	108289	125622	142917	160168	47
14	004072	021524	038969	056402	073818	091212	108578	125910	143205	160455	46
15	004363	021815	039260	056693	074108	091502	108867	126199	143493	160743	45
16	004654	022106	039550	056983	074399	091791	109156	126488	143780	161030	44
17	004945	022397	039841	057274	074689	092081	109445	126776	144068	161317	43
18	005236	022687	040132	057564	074979	092371	109734	127065	144356	161604	42
19	005527	022978	040422	057854	075269	092660	110023	127353	144644	161891	41
20	005818	023269	040713	058145	075559	092950	110313	127642	144932	162178	40
21	006109	023560	041004	058435	075849	093239	110602	127930	145220	162465	39
22	006399	023851	041294	058726	076139	093529	110891	128219	145507	162752	38
23	006690	024141	041585	059016	076429	093819	111180	128507	145795	163039	37
24	006981	024432	041876	059306	076719	094108	111469	128796	146083	163326	36
25	007272	024723	042166	059597	077009	094398	111758	129084	146371	163613	35
26	007563	025014	042457	059887	077299	094687	112047	129373	146659	163900	34
27	007854	025305	042748	060177	077589	094977	112336	129661	146946	164187	33
28	008145	025595	043038	060468	077879	095267	112625	129949	147234	164474	32
29	008436	025886	043329	060758	078169	095556	112914	130238	147522	164761	31
30	008727	026177	043619	061049	078459	095846	113203	130526	147809	165048	30
31	009017	026468	043910	061339	078749	096135	113492	130815	148097	165334	29
32	009308	026759	044201	061629	079039	096425	113781	131103	148385	165621	28
33	009599	027049	044491	061920	079329	096714	114070	131391	148672	165908	27
34	009890	027340	044782	062210	079619	097004	114359	131680	148960	166195	26
35	010181	027631	045072	062500	079909	097293	114648	131968	149248	166482	25
36	010472	027922	045363	062791	080199	097583	114937	132256	149535	166769	24
37	010763	028212	045654	063081	080489	097872	115226	132545	149823	167056	23
38	011054	028503	045944	063371	080779	098162	115515	132833	150111	167342	22
39	011344	028794	046235	063661	081069	098451	115804	133121	150398	167629	21
40	011635	029085	046525	063952	081359	098741	116093	133410	150686	167916	20
41	011926	029375	046816	064242	081649	099030	116382	133698	150973	168203	19
42	012217	029666	047106	064532	081939	099320	116671	133986	151261	168489	18
43	012508	029957	047397	064823	082228	099609	116960	134274	151548	168776	17
44	012799	030248	047688	065113	082518	099899	117249	134563	151836	169063	16
45	013090	030539	047978	065403	082808	100188	117537	134851	152123	169350	15
46	013380	030829	048269	065693	083098	100477	117826	135139	152411	169636	14
47	013671	031120	048559	065984	083388	100767	118115	135427	152698	169923	13
48	013962	031411	048850	066274	083678	101056	118404	135716	152986	170209	12
49	014253	031702	049140	066564	083968	101346	118693	136004	153273	170496	11
50	014544	031992	049431	066854	084258	101635	118982	136292	153561	170783	10
51	014835	032283	049721	067145	084547	101924	119270	136580	153848	171069	
52	015126	032574	050012	067435	084837	102214	119559	136868	154136	171356	
53	015416	032864	050302	067725	085127	102503	119848	137156	154423	171643	
54	015707	033155	050593	068015	085417	102793	120137	137445	154710	171929	
55	015998	033446	050883	068306	085707	103082	120426	137733	154998	172216	
56	016289	033737	051174	068596	085997	103371	120714	138021	155285	172502	
57	016580	034027	051464	068886	086286	103661	121003	138309	155572	172789	
58	016871	034318	051755	069176	086576	103950	121292	138597	155860	173075	
59	017162	034609	052045	069466	086866	104239	121581	138885	156147	173362	
60	017452	034899	052336	069756	087156	104528	121869	139173	156434	173648	
M	89°	88°	87°	86°	85°	84°	83°	82°	81°	80°	

Natural Co-sines.

Diff. to 100"	485	485	484	484	483	483	482	481	480	478

M	10°	11°	12°	13°	14°	15°	16°	17°	18°	19°	M
0	173648	190809	207912	224951	241922	258819	275637	292372	309017	325568	60
1	173935	191095	208196	225234	242204	259100	275917	292650	309294	325843	59
2	174221	191380	208481	225518	242486	259381	276197	292928	309570	326118	58
3	174508	191666	208765	225801	242769	259662	276476	293206	309847	326393	57
4	174794	191951	209050	226085	243051	259943	276756	293484	310123	326668	56
5	175080	192237	209334	226368	243333	260224	277035	293762	310400	326943	55
6	175367	192522	209619	226651	243615	260505	277315	294040	310676	327218	54
7	175653	192807	209903	226935	243897	260785	277594	294318	310953	327493	53
8	175939	193093	210187	227218	244179	261066	277874	294596	311229	327768	52
9	176226	193378	210472	227501	244461	261347	278153	294874	311506	328042	51
10	176512	193664	210756	227784	244743	261628	278432	295152	311782	328317	50
11	176798	193949	211040	228068	245025	261908	278712	295430	312059	328592	49
12	177085	194234	211325	228351	245307	262189	278991	295708	312335	328867	48
13	177371	194520	211609	228634	245589	262470	279270	295986	312611	329141	47
14	177657	194805	211893	228917	245871	262751	279550	296264	312888	329416	46
15	177944	195090	212178	229200	246153	263031	279829	296542	313164	329691	45
16	178230	195376	212462	229484	246435	263312	280108	296819	313440	329965	44
17	178516	195661	212746	229767	246717	263592	280388	297097	313716	330240	43
18	178802	195946	213030	230050	246999	263873	280667	297375	313992	330514	42
19	179088	196231	213315	230333	247281	264154	280946	297653	314269	330789	41
20	179375	196517	213599	230616	247563	264434	281225	297930	314545	331063	40
21	179661	196802	213883	230899	247845	264715	281504	298208	314821	331338	39
22	179947	197087	214167	231182	248126	264095	281783	298486	315097	331612	38
23	180233	197372	214451	231465	248408	265276	282062	298763	315373	331887	37
24	180519	197657	214735	231748	248690	265556	282341	299041	315649	332161	36
25	180805	197942	215019	232031	248972	265837	282620	299318	315925	332435	35
26	181091	198228	215303	232314	249253	266117	282900	299596	316201	332710	34
27	181377	198513	215588	232597	249535	266397	283179	299873	316477	332984	33
28	181663	198798	215872	232880	249817	266678	283457	300151	316753	333258	32
29	181950	199083	216156	233163	250098	266958	283736	300428	317029	333533	31
30	182236	199368	216440	233445	250380	267238	284015	300706	317305	333807	30
31	182522	199653	216724	233728	250662	267519	284294	300983	317580	334081	29
32	182808	199938	217008	234011	250943	267799	284573	301261	317856	334355	28
33	183094	200223	217292	234294	251225	268079	284852	301538	318132	334629	27
34	183379	200508	217575	234577	251506	268359	285131	301815	318408	334903	26
35	183665	200793	217859	234859	251788	268640	285410	302093	318684	335178	25
36	183951	201078	218143	235142	252069	268920	285688	302370	318959	335452	24
37	184237	201363	218427	235425	252351	269200	285967	302647	319235	335726	23
38	184523	201648	218711	235708	252632	269480	286246	302924	319511	336000	22
39	184809	201933	218995	235990	252914	269760	286525	303202	319786	336274	21
40	185095	202218	219279	236273	253195	270040	286803	303479	320062	336547	20
41	185381	202502	219562	236556	253477	270320	287082	303756	320337	336821	19
42	185667	202787	219846	236838	253758	270600	287361	304033	320613	337095	18
43	185952	203072	220130	237121	254039	270880	287639	304310	320889	337369	17
44	186238	203357	220414	237403	254321	271160	287918	304587	321164	337643	16
45	186524	203642	220697	237686	254602	271440	288196	304864	321439	337917	15
46	186810	203927	220981	237968	254883	271720	288475	305141	321715	338190	14
47	187096	204211	221265	238251	255165	272000	288753	305418	321990	338464	13
48	187381	204496	221548	238533	255446	272280	289032	305695	322266	338738	12
49	187667	204781	221832	238816	255727	272560	289310	305972	322541	339012	11
50	187953	205065	222116	239098	256008	272840	289589	306249	322816	339285	10
51	188238	205350	222399	239381	256289	273120	289867	306526	323092	339559	9
52	188524	205635	222683	239663	256571	273400	290145	306803	323367	339832	8
53	188810	205920	222967	239946	256852	273679	290424	307080	323642	340106	7
54	189095	206204	223250	240228	257133	273959	290702	307357	323917	340380	6
55	189381	206489	223534	240510	257414	274239	290981	307633	324193	340653	5
56	189667	206773	223817	240793	257695	274519	291259	307910	324468	340927	4
57	189952	207058	224101	241075	257976	274798	291537	308187	324743	341200	3
58	190238	207343	224384	241357	258257	275078	291815	308464	325018	341473	2
59	190523	207627	224668	241640	258538	275358	292094	308740	325293	341747	1
60	190809	207912	224951	241922	258819	275637	292372	309017	325568	342020	0
	79°	78°	77°	76°	75°	74°	73°	72°	71°	70°	M

Natural Co-sines.

Diff. to 100"	477	475	473	471	469	467	465	462	460	457

M	20°	21°	22°	23°	24°	25°	26°	27°	28°	29°	
0	342020	358368	374607	390731	406737	422618	438371	453990	469472	484810	6
1	342293	358640	374876	390999	407002	422882	438633	454250	469728	485064	5
2	342567	358911	375146	391267	407268	423145	438894	454509	469985	485318	5
3	342840	359183	375416	391534	407534	423409	439155	454768	470242	485573	5
4	343113	359454	375685	391802	407799	423673	439417	455027	470499	485827	5
5	343387	359725	375955	392070	408065	423936	439678	455286	470755	486081	5
6	343660	359997	376224	392337	408330	424199	439939	455545	471012	486335	5
7	343933	360268	376494	392605	408596	424463	440200	455804	471268	486590	5
8	344206	360540	376763	392872	408861	424726	440462	456063	471525	486844	5
9	344479	360811	377033	393140	409127	424990	440723	456322	471782	487098	5
10	344752	361082	377302	393407	409392	425253	440984	456580	472038	487352	5
11	345025	361353	377571	393675	409658	425516	441245	456839	472294	487606	4
12	345298	361625	377841	393942	409923	425779	441506	457098	472551	487860	4
13	345571	361896	378110	394209	410188	426042	441767	457357	472807	488114	4
14	345844	362167	378379	394477	410454	426306	442028	457615	473063	488367	4
15	346117	362438	378649	394744	410719	426569	442289	457874	473320	488621	4
16	346390	362709	378918	395011	410984	426832	442550	458133	473576	488875	4
17	346663	362980	379187	395278	411249	427095	442810	458391	473832	489129	4
18	346936	363251	379456	395546	411514	427358	443071	458650	474088	489382	4
19	347208	363522	379725	395813	411779	427621	443332	458908	474344	489636	4
20	347481	363793	379994	396080	412045	427884	443593	459166	474600	489890	4
21	347754	364064	380263	396347	412310	428147	443853	459425	474856	490143	3
22	348027	364335	380532	396614	412575	428410	444114	459683	475112	490397	3
23	348299	364606	380801	396881	412840	428672	444375	459942	475368	490650	3
24	348572	364877	381070	397148	413104	428935	444635	460200	475624	490904	3
25	348845	365148	381339	397415	413369	429198	444896	460458	475880	491157	3
26	349117	365418	381608	397682	413634	429461	445156	460716	476136	491411	3
27	349390	365689	381877	397949	413899	429723	445417	460974	476392	491664	3
28	349662	365960	382146	398215	414164	429986	445677	461232	476647	491917	3
29	349935	366231	382415	398482	414429	430249	445937	461491	476903	492170	3
30	350207	366501	382683	398749	414693	430511	446198	461749	477159	492424	3
31	350480	366772	382952	399016	414958	430774	446458	462007	477414	492677	2
32	350752	367042	383221	399283	415223	431036	446718	462265	477670	492930	2
33	351025	367313	383490	399549	415487	431299	446979	462523	477925	493183	2
34	351297	367584	383758	399816	415752	431561	447239	462780	478181	493436	2
35	351569	367854	384027	400082	416016	431823	447499	463038	478436	493689	2
36	351842	368125	384295	400349	416281	432086	447759	463296	478692	493942	2
37	352114	368395	384564	400616	416545	432348	448019	463554	478947	494195	2
38	352386	368665	384832	400882	416810	432610	448279	463812	479203	494448	2
39	352658	368936	385101	401149	417074	432873	448539	464069	479458	494700	2
40	352931	369206	385369	401415	417338	433135	448799	464327	479713	494953	2
41	353203	369476	385638	401681	417603	433397	449059	464584	479968	495206	1
42	353475	369747	385906	401948	417867	433659	449319	464842	480223	495459	1
43	353747	370017	386174	402214	418131	433921	449579	465100	480479	495711	1
44	354019	370287	386443	402480	418396	434183	449839	465357	480734	495964	1
45	354291	370557	386711	402747	418660	434445	450098	465615	480989	496217	1
46	354563	370828	386979	403013	418924	434707	450358	465872	481244	496469	1
47	354835	371098	387247	403279	419188	434969	450618	466129	481499	496722	1
48	355107	371368	387516	403545	419452	435231	450878	466387	481754	496974	1
49	355379	371638	387784	403811	419716	435493	451137	466644	482009	497226	1
50	355651	371908	388052	404078	419980	435755	451397	466901	482263	497479	1
51	355923	372178	388320	404344	420244	436017	451656	467158	482518	497731	
52	356194	372448	388588	404610	420508	436278	451916	467416	482773	497983	
53	356466	372718	388856	404876	420772	436540	452175	467673	483028	498236	
54	356738	372988	389124	405142	421036	436802	452435	467930	483282	498488	
55	357010	373258	389392	405408	421300	437063	452694	468187	483537	498740	
56	357281	373528	389660	405673	421563	437325	452953	468444	483792	498992	
57	357553	373797	389928	405939	421827	437587	453213	468701	484046	499244	
58	357825	374067	390196	406205	422091	437848	453472	468958	484301	499496	
59	358096	374337	390463	406471	422355	438110	453731	469215	484555	499748	
60	358368	374607	390731	406737	422618	438371	453990	469472	484810	500000	
M	69°	68°	67°	66°	65°	64°	63°	62°	61°	60°	

Natural Co-Sines

Diff.

′	30°	31°	32°	33°	34°	35°	36°	37°	38°	39°	′
0	500000	515038	529919	544639	559193	573576	587785	601815	615661	629320	60
1	500252	515287	530166	544883	559434	573815	588021	602047	615891	629546	59
2	500504	515537	530413	545127	559675	574053	588256	602280	616120	629772	58
3	500756	515786	530659	545371	559916	574291	588491	602512	616349	629998	57
4	501007	516035	530906	545615	560157	574529	588726	602744	616578	630224	56
5	501259	516284	531152	545858	560398	574767	588961	602976	616807	630450	55
6	501511	516533	531399	546102	560639	575005	589196	603208	617036	630676	54
7	501762	516782	531645	546346	560880	575243	589431	603440	617265	630902	53
8	502014	517031	531891	546589	561121	575481	589666	603672	617494	631127	52
9	502266	517280	532138	546833	561361	575719	589901	603904	617722	631353	51
10	502517	517529	532384	547076	561602	575957	590136	604136	617951	631578	50
11	502769	517778	532630	547320	561843	576195	590371	604367	618180	631804	49
12	503020	518027	532876	547563	562083	576432	590606	604599	618408	632029	48
13	503271	518276	533122	547807	562324	576670	590840	604831	618637	632255	47
14	503523	518525	533368	548050	562564	576908	591075	605062	618865	632480	46
15	503774	518773	533615	548293	562805	577145	591310	605294	619094	632705	45
16	504025	519022	533861	548536	563045	577383	591544	605526	619322	632931	44
17	504276	519271	534106	548780	563286	577620	591779	605757	619551	633156	43
18	504528	519519	534352	549023	563526	577858	592013	605988	619779	633381	42
19	504779	519768	534598	549266	563766	578095	592248	606220	620007	633606	41
20	505030	520016	534844	549509	564007	578332	592482	606451	620235	633831	40
21	505281	520265	535090	549752	564247	578570	592716	606682	620464	634056	39
22	505532	520513	535335	549995	564487	578807	592951	606914	620692	634281	38
23	505783	520761	535581	550238	564727	579044	593185	607145	620920	634506	37
24	506034	521010	535827	550481	564967	579281	593419	607376	621148	634731	36
25	506285	521258	536072	550724	565207	579518	593653	607607	621376	634955	35
26	506535	521506	536318	550966	565447	579755	593887	607838	621604	635180	34
27	506786	521754	536563	551209	565687	579992	594121	608069	621831	635405	33
28	507037	522002	536809	551452	565927	580229	594355	608300	622059	635629	32
29	507288	522251	537054	551694	566166	580466	594589	608531	622287	635854	31
30	507538	522499	537300	551937	566406	580703	594823	608761	622515	636078	30
31	507789	522747	537545	552180	566646	580940	595057	608992	622742	636303	29
32	508040	522995	537790	552422	566886	581176	595290	609223	622970	636527	28
33	508290	523242	538035	552664	567125	581413	595524	609454	623197	636751	27
34	508541	523490	538281	552907	567365	581650	595758	609684	623425	636976	26
35	508791	523738	538526	553149	567604	581886	595991	609915	623652	637200	25
36	509041	523986	538771	553392	567844	582123	596225	610145	623880	637424	24
37	509292	524234	539016	553634	568083	582359	596458	610376	624107	637648	23
38	509542	524481	539261	553876	568323	582596	596692	610606	624334	637872	22
39	509792	524729	539506	554118	568562	582832	596925	610836	624561	638096	21
40	510043	524977	539751	554360	568801	583069	597159	611067	624789	638320	20
41	510293	525224	539996	554602	569040	583305	597392	611297	625016	638544	19
42	510543	525472	540240	554844	569280	583541	597625	611527	625243	638768	18
43	510793	525719	540485	555086	569519	583777	597858	611757	625470	638992	17
44	511043	525967	540730	555328	569758	584014	598092	611987	625697	639215	16
45	511293	526214	540974	555570	569997	584250	598325	612217	625923	639439	15
46	511543	526461	541219	555812	570236	584486	598558	612447	626150	639663	14
47	511793	526709	541464	556054	570475	584722	598791	612677	626377	639886	13
48	512043	526956	541708	556296	570714	584958	599024	612907	626604	640110	12
49	512293	527203	541953	556537	570952	585194	599256	613137	626830	640333	11
50	512543	527450	542197	556779	571191	585429	599489	613367	627057	640557	10
51	512792	527697	542442	557021	571430	585665	599722	613596	627284	640780	9
52	513042	527944	542686	557262	571669	585901	599955	613826	627510	641003	8
53	513292	528191	542930	557504	571907	586137	600188	614056	627737	641226	7
54	513541	528438	543174	557745	572146	586372	600420	614285	627963	641450	6
55	513791	528685	543419	557987	572384	586608	600653	614515	628189	641673	5
56	514040	528932	543663	558228	572623	586844	600885	614744	628416	641896	4
57	514290	529179	543907	558469	572861	587079	601118	614974	628642	642119	3
58	514539	529426	544151	558710	573100	587314	601350	615203	628868	642342	2
59	514789	529673	544395	558952	573338	587550	601583	615432	629094	642565	1
60	515038	529919	544639	559193	573576	587785	601815	615661	629320	642788	0
′	59°	58°	57°	56°	55°	54°	53°	52°	51°	50°	′

Natural Co-sines.

tEto 60″	418	413	409	404	399	394	390	385	380	374

M	40°	41°	42°	43°	44°	45°	46°	47°	48°	49°	M
0	642788	656059	669131	681998	694658	707107	719340	731354	743145	754710	60
1	643010	656279	669347	682211	694868	707312	719542	731552	743339	754900	59
2	643233	656498	669563	682424	695077	707518	719744	731750	743534	755091	58
3	643456	656717	669779	682636	695286	707723	719946	731949	743728	755282	57
4	643679	656937	669995	682849	695495	707929	720148	732147	743923	755472	56
5	643901	657156	670211	683061	695704	708134	720349	732345	744117	755663	55
6	644124	657375	670427	683274	695913	708340	720551	732543	744312	755853	54
7	644346	657594	670642	683486	696122	708545	720753	732741	744506	756044	53
8	644569	657814	670858	683698	696330	708750	720954	732939	744700	756234	52
9	644791	658033	671074	683911	696539	708956	721156	733137	744894	756425	51
10	645013	658252	671289	684123	696748	709161	721357	733334	745088	756615	50
11	645236	658471	671505	684335	696957	709366	721559	733532	745282	756805	49
12	645458	658689	671721	684547	697165	709571	721760	733730	745476	756995	48
13	645680	658908	671936	684759	697374	709776	721962	733927	745670	757185	47
14	645902	659127	672151	684971	697582	709981	722163	734125	745864	757375	46
15	646124	659346	672367	685183	697790	710185	722364	734323	746057	757565	45
16	646346	659565	672582	685395	697999	710390	722565	734520	746251	757755	44
17	646568	659783	672797	685607	698207	710595	722766	734717	746445	757945	43
18	646790	660002	673013	685818	698415	710799	722967	734915	746638	758134	42
19	647012	660220	673228	686030	698623	711004	723168	735112	746832	758324	41
20	647233	660439	673443	686242	668832	711209	723369	735309	747025	758514	40
21	647455	660657	673658	686453	699040	711413	723570	735506	747218	758703	39
22	647677	660875	673873	686665	699248	711617	723771	735703	747412	758893	38
23	647898	661094	674088	686876	699455	711822	723971	735900	747605	759082	37
24	648120	661312	674302	687088	699663	712026	724172	736097	747798	759271	36
25	648341	661530	674517	687299	699871	712230	724372	736294	747991	759461	35
26	648563	661748	674732	687510	700079	712434	724573	736491	748184	759650	34
27	648784	661966	674947	687721	700287	712639	724773	736687	748377	759839	33
28	649006	662184	675161	687932	700494	712843	724974	736884	748570	760028	32
29	649227	662402	675376	688144	700702	713047	725174	737081	748763	760217	31
30	649448	662620	675590	688355	700909	713250	725374	737277	748956	760406	30
31	649669	662838	675805	688566	701117	713454	725575	737474	749148	760595	29
32	649890	663056	676019	688776	701324	713658	725775	737670	749341	760784	28
33	650111	663273	676233	688987	701531	713862	725975	737867	749534	760972	27
34	650332	663491	676448	689198	701739	714066	726175	738063	749726	761161	26
35	650553	663709	676662	689409	701946	714269	726375	738259	749919	761350	25
36	650774	663926	676876	689620	702153	714473	726575	738455	750111	761538	24
37	650995	664144	677090	689830	702360	714676	726775	738651	750303	761727	23
38	651216	664361	677304	690041	702567	714880	726974	738848	750496	761915	22
39	651437	664579	677518	690251	702774	715083	727174	739043	750688	762104	21
40	651657	664796	677732	690462	702981	715286	727374	739239	750880	762292	20
41	651878	665013	677946	690672	703188	715490	727573	739435	751072	762480	19
42	652098	665230	678160	690882	703395	715693	727773	739631	751264	762668	18
43	652319	665448	678373	691093	703601	715896	727972	739827	751456	762856	17
44	652539	665665	678587	691303	703808	716099	728172	740023	751648	763044	16
45	652760	665882	678801	691513	704015	716302	728371	740218	751840	763232	15
46	652980	666099	679014	691723	704221	716505	728570	740414	752032	763420	14
47	653200	666316	679228	691933	704428	716708	728769	740609	752223	763608	13
48	653421	666532	679441	692143	704634	716911	728969	740805	752415	763796	12
49	653641	666749	679654	692353	704841	717113	729168	741000	752606	763984	11
50	653861	666966	679868	692563	705047	717316	729367	741195	752798	764171	10
51	654081	667183	680081	692773	705253	717519	729566	741391	752989	764359	9
52	654301	667399	680295	692983	705459	717721	729765	741586	753181	764547	8
53	654521	667616	680508	693192	705665	717924	729963	741781	753372	764734	7
54	654741	667833	680721	693402	705872	718126	730162	741976	753563	764921	6
55	654961	668049	680934	693611	706078	718329	730361	742171	753755	765109	5
56	655180	668265	681147	693821	706284	718531	730560	742366	753946	765296	4
57	655400	668482	681360	694030	706489	718733	730758	742561	754137	765483	3
58	655620	668698	681573	694240	706695	718936	730957	742755	754328	765670	2
59	655839	668914	681786	694449	706901	719138	731155	742950	754519	765857	1
60	656059	669131	681998	694658	707107	719340	731354	743145	754710	766044	0
M	49°	48°	47°	46°	45°	44°	43°	42°	41°	40°	M

Natural Co-sines.

Diff. to 100"	369	363	357	352	346	340	334	327	321	315

50°	51°	52°	53°	54°	55°	56°	57°	58°	59°	′
766044	777146	788011	798636	809017	819152	829038	838671	848048	857167	60
766231	777329	788190	798811	809188	819319	829200	838829	848202	857317	59
766418	777512	788369	798985	809359	819486	829363	838987	848356	857467	58
766605	777695	788548	799160	809530	819652	829525	839146	848510	857616	57
766792	777878	788727	799335	809700	819819	829688	839304	848664	857766	56
766979	778060	788905	799510	809871	819985	829850	839462	848818	857915	55
767165	778243	789084	799685	810042	820152	830012	839620	848972	858065	54
767352	778426	789263	799859	810212	820318	830174	839778	849125	858214	53
767538	778608	789441	800034	810383	820485	830337	839936	849279	858364	52
767725	778791	789620	800208	810553	820651	830499	840094	849433	858513	51
767911	778973	789798	800383	810723	820817	830661	840251	849586	858662	50
768097	779156	789977	800557	810894	820983	830823	840409	849739	858811	49
768284	779338	790155	800731	811064	821149	830984	840567	849893	858960	48
768470	779520	790333	800906	811234	821315	831146	840724	850046	859109	47
768656	779702	790511	801080	811404	821481	831308	840882	850199	859258	46
768842	779884	790690	801254	811574	821647	831470	841039	850352	859406	45
769028	780067	790868	801428	811744	821813	831631	841196	850505	859555	44
769214	780249	791046	801602	811914	821978	831793	841354	850658	859704	43
769400	780430	791224	801776	812084	822144	831954	841511	850811	859852	42
769585	780612	791401	801949	812253	822310	832115	841668	850964	860001	41
769771	780794	791579	802123	812423	822475	832277	841825	851117	860149	40
769957	780976	791757	802297	812592	822641	832438	841982	851269	860297	39
770142	781157	791935	802470	812762	822806	832599	842139	851422	860445	38
770328	781339	792112	802644	812931	822971	832760	842296	851575	860594	37
770513	781520	792290	802817	813101	823136	832921	842452	851727	860742	36
770699	781702	792467	802991	813270	823302	833082	842609	851879	860890	35
770884	781883	792644	803164	813439	823467	833243	842766	852032	861038	34
771069	782065	792822	803337	813608	823632	833404	842922	852184	861186	33
771254	782246	792999	803511	813778	823797	833565	843079	852336	861334	32
771440	782427	793176	803684	813947	823961	833725	843235	852488	861481	31
771625	782608	793353	803857	814116	824126	833886	843391	852640	861629	30
771810	782789	793530	804030	814284	824291	834046	843548	852792	861777	29
771995	782970	793707	804203	814453	824456	834207	843704	852944	861924	28
772179	783151	793884	804376	814622	824620	834367	843860	853096	862072	27
772364	783332	794061	804548	814791	824785	834527	844016	853248	862219	26
772549	783513	794238	804721	814959	824949	834688	844172	853399	862366	25
772734	783693	794415	804894	815128	825113	834848	844328	853551	862514	24
772918	783874	794591	805066	815296	825278	835008	844484	853702	862661	23
773103	784055	794768	805239	815465	825442	835168	844640	853854	862808	22
773287	784235	794944	805411	815633	825606	835328	844795	854005	862955	21
773472	784416	795121	805584	815801	825770	835488	844951	854156	863102	20
773656	784596	795297	805756	815969	825934	835648	845106	854308	863249	19
773840	784776	795473	805928	816138	826098	835807	845262	854459	863396	18
774024	784957	795650	806100	816306	826262	835967	845417	854610	863542	17
774209	785137	795826	806273	816474	826426	836127	845573	854761	863689	16
774393	785317	796002	806445	816642	826590	836286	845728	854912	863836	15
774577	785497	796178	806617	816809	826753	836446	845883	855063	863982	14
774761	785677	796354	806788	816977	826917	836605	846038	855214	864128	13
774944	785857	796530	806960	817145	827081	836764	846193	855364	864275	12
775128	786037	796706	807132	817313	827244	836924	846348	855515	864421	11
775312	786217	796882	807304	817480	827407	837083	846503	855665	864567	10
775496	786396	797057	807475	817648	827571	837242	846658	855816	864713	9
775679	786576	797233	807647	817815	827734	837401	846813	855966	864859	8
775863	786756	797408	807818	817982	827897	837560	846967	856117	865005	7
776046	786935	797584	807990	818150	828060	837719	847122	856267	865151	6
776230	787114	797759	808161	818317	828223	837878	847277	856417	865297	5
776413	787294	797935	808333	818484	828386	838036	847431	856567	865442	4
776596	787473	798110	808504	818651	828549	838195	847585	856718	865588	3
776780	787652	798285	808675	818818	828712	838354	847740	856868	865733	2
776963	787832	798460	808846	818985	828875	838512	847894	857017	865879	1
777146	788011	798636	809017	819152	829038	838671	848048	857167	866025	0
39°	38°	37°	36°	35°	34°	33°	32°	31°	30°	′

Natural Co-sines.

Diff. to 100″										
	309	302	295	288	282	275	268	260	253	246

M	60°	61°	62°	63°	64°	65°	66°	67°	68°	69°	M
0	866025	874620	882948	891007	898794	906308	913545	920505	927184	933580	60
1	866171	874761	883084	891139	898922	906431	913664	920618	927293	933685	59
2	866316	874902	883221	891270	899049	906554	913782	92073	927402	933789	58
3	866461	875042	883357	891402	899176	906676	913900	920846	927510	933893	57
4	866607	845183	883493	891534	8993 4	906799	914018	920959	927619	933997	56
5	866752	875324	883629	891666	899431	906922	914136	921072	927728	934101	55
6	866897	875465	883766	891798	899558	907044	914254	921185	927836	934204	54
7	867042	875605	883902	891929	899685	907166	914372	921299	927945	934308	53
8	867187	875746	884038	892061	899812	907289	914490	921412	928053	934412	52
9	867331	875886	884174	892192	899939	907411	914607	921525	928161	934515	51
10	867476	876026	884309	892323	900065	907533	914725	921638	928270	934619	50
11	867621	876167	884445	892455	900192	907655	914842	921750	928378	934722	49
12	867765	876307	884581	892586	900319	907777	914960	921863	928486	934 26	48
13	867910	876447	884717	892717	900445	907899	915077	921976	928594	934929	47
14	868054	876587	884852	892848	900572	908021	915194	922088	928702	935034	46
15	868199	876727	884988	892979	900698	908143	915311	922201	928810	935135	45
16	868343	876867	885123	893110	900825	908265	915429	922313	928917	935238	44
17	868487	877006	885258	893241	900951	908387	915546	922426	929025	935341	43
18	868632	877146	885394	893371	901077	908508	915663	922538	929133	935444	42
19	868776	877286	885529	893502	901203	908630	915779	922650	929240	935547	41
20	868920	877425	885664	893633	901329	908751	915896	922762	929348	935650	40
21	869064	877565	885799	893763	901455	908872	916013	922874	929455	935752	39
22	869207	877704	885934	893894	901581	908994	916130	922986	929562	935855	38
23	869351	877844	886069	894024	901707	909115	916246	923098	929669	935957	37
24	869495	877983	886204	894154	901833	909236	916363	923210	929776	936060	36
25	869639	878122	886338	894284	901958	909357	916479	923322	929884	936162	35
26	869782	878261	886473	894415	902084	909478	916595	923434	929990	936264	34
27	869926	878400	886608	894545	902209	909599	916712	923545	930097	936366	33
28	870069	878539	886742	894675	902335	909720	916828	923657	930204	936468	32
29	870212	878678	886876	894805	902460	909841	916944	923768	930311	936570	31
30	870356	878817	887011	894934	902585	909961	917060	923880	930418	936672	30
31	870499	878956	887145	895064	902710	910082	917176	923991	930524	936774	29
32	870642	879095	887279	895194	902836	910202	917292	924102	930631	936876	28
33	870785	879233	887413	895323	902961	910323	917408	924213	930737	936977	27
34	870928	879372	887548	895453	903086	910443	917523	924324	930843	937079	26
35	871071	879510	887681	895582	903210	910563	917639	924435	930950	937181	25
36	871214	879649	887815	895712	903335	910684	917755	924546	931056	937282	24
37	871357	879787	887949	895841	903460	910804	917870	924657	931162	937383	23
38	871499	879925	888083	895970	903585	910924	917986	924768	931268	937485	22
39	871642	880063	888217	896099	903709	911044	918101	924878	931374	937586	21
40	871784	880201	888350	896229	903834	911164	918216	924989	931480	937687	20
41	871927	880339	888484	896358	903958	911284	918331	925099	931586	937788	19
42	872069	880477	888617	896486	904083	911403	918446	925210	931691	937889	18
43	872212	880615	888751	896615	904207	911523	918561	925320	931797	937990	17
44	872354	880753	888884	896744	904331	911643	918676	925430	931902	938091	16
45	872496	880891	889017	896873	904455	911762	918791	925541	932008	938191	15
46	872638	881028	889150	897001	904579	911881	918906	925651	932113	938292	14
47	872780	881166	889283	897130	904703	912001	919021	925761	932219	938393	13
48	872922	881303	889416	897258	904827	912120	919135	925871	932324	938493	12
49	873064	881441	889549	897387	904951	912239	919250	925980	932429	938593	11
50	873206	881578	889682	897515	905075	912358	919364	926090	932534	938694	10
51	873347	881716	889815	897643	905198	912477	919479	926200	932639	938794	
52	873489	881853	889948	897771	995322	912596	919593	926310	932744	938894	
53	873631	881990	890080	897900	905445	912715	919707	926419	932849	938994	
54	873772	882157	890213	898028	905569	912834	919821	926529	932954	939094	
55	873914	882264	890345	898156	905692	912953	919936	926638	933058	939194	
56	874055	882401	890478	898283	905815	913072	920050	926747	933163	939294	
57	874196	882538	890610	898411	905939	913190	920164	926857	933267	939394	
58	874338	882674	890742	898539	906062	913309	920277	926966	933372	939493	
59	874479	882811	890874	898666	906185	913427	920391	927075	933476	939593	
60	874620	882948	891007	898794	906308	913545	920505	927184	933580	939693	
M	29°	28°	27°	26°	25°	24°	23°	22°	21°	20°	M

Natural Co-sines

Diff to 0" 239	231	224	216	209	201	193	185	178	170

M	70°	71°	72°	73°	74°	75°	76°	77°	78°	79°	M
0	939693	945519	951057	956305	961262	965926	970296	974370	978148	981627	60
1	939792	945613	951146	956390	961342	966001	970366	974435	978208	981683	59
2	939891	945708	951236	956475	961422	966076	970436	974501	978268	981738	58
3	939991	945802	951326	956560	961502	966151	970506	974566	978329	981793	57
4	940090	945897	951415	956644	961582	966226	970577	974631	978389	981849	56
5	940189	945991	951505	956729	961662	966301	970647	974696	978449	981904	55
6	940288	946085	951594	956814	961741	966376	970716	974761	978509	981959	54
7	940387	946180	951684	956898	961821	966451	970786	974826	978569	982014	53
8	940486	946274	951773	956983	961901	966526	970856	974891	978629	982069	52
9	940585	946368	951862	957067	961980	966600	970926	974956	978689	982123	51
10	940684	946462	951951	957151	962059	966675	970995	975020	978748	982178	50
11	940782	946555	952040	957235	962139	966749	971065	975085	978808	982233	49
12	940881	946649	952129	957319	962218	966823	971134	975149	978867	982287	48
13	940979	946743	952218	957404	962297	966898	971204	975214	978927	982342	47
14	941078	946837	952307	957487	962376	966972	971273	975278	978986	982396	46
15	941176	946930	952396	957571	962455	967046	971342	975342	979045	982450	45
16	941274	947024	952484	957655	962534	967120	971411	975406	979105	982505	44
17	941372	947117	952573	957739	962613	967194	971480	975471	979164	982559	43
18	941471	947210	952661	957822	962692	967268	971549	975535	979223	982613	42
19	941569	947304	952750	957906	962770	967342	971618	975598	979282	982667	41
20	941666	947397	952838	957990	962849	967415	971687	975662	979341	982721	40
21	941764	947490	952926	958073	962928	967489	971755	975726	979399	982774	39
22	941862	947583	953015	958156	963006	967562	971824	975790	979458	982828	38
23	941960	947676	953103	958239	963084	967636	971893	975853	979517	982882	37
24	942057	947768	953191	958323	963163	967709	971961	975917	979575	982935	36
25	942155	947861	953279	958406	963241	967782	972030	975980	979634	982989	35
26	942252	947954	953366	958489	963319	967856	972098	976044	979692	983042	34
27	942350	948046	953454	958572	963397	967929	972166	976107	979750	983096	33
28	942447	948139	953542	958654	963475	968002	972234	976170	979809	983149	32
29	942544	948231	953629	958737	963553	968075	972302	976233	979867	983202	31
30	942641	948324	953717	958820	963630	968148	972370	976296	979925	983255	30
31	942739	948416	953804	958902	963708	968220	972438	976359	979983	983308	29
32	942836	948508	953892	958985	963786	968293	972506	976422	980041	983361	28
33	942932	948600	953979	959067	963863	968366	972573	976485	980098	983414	27
34	943029	948692	954066	959150	963941	968438	972641	976547	980156	983466	26
35	943126	948784	954153	959232	964018	968511	972708	976610	980214	983519	25
36	943223	948876	954240	959314	964095	968583	972776	976672	980271	983571	24
37	943319	948968	954327	959396	964173	968656	972843	976735	980329	983624	23
38	943416	949059	954414	959478	964250	968728	972911	976797	980386	983676	22
39	943512	949151	954501	959560	964327	968800	972978	976859	980443	983729	21
40	943609	949243	954588	959642	964404	968872	973045	976921	980500	983781	20
41	943705	949334	954674	959724	964481	968944	973112	976984	980558	983833	19
42	943801	949425	954761	959805	964557	969016	973179	977046	980615	983885	18
43	943897	949517	954847	959887	964634	969088	973246	977108	980672	983937	17
44	943993	949608	954934	959968	964711	969159	973313	977169	980728	983989	16
45	944089	949699	955020	960050	964787	969231	973379	977231	980785	984041	15
46	944185	949790	955106	960131	964864	969302	973446	977293	980842	984092	14
47	944281	949881	955192	960212	964940	969374	973512	977354	980899	984144	13
48	944376	949972	955278	960294	965016	969445	973579	977416	980955	984196	12
49	944472	950063	955364	960375	965093	969517	973645	977477	981012	984247	11
50	944568	950154	955450	960456	965169	969588	973712	977539	981068	984298	10
51	944663	950244	955536	960537	965245	969659	973778	977600	981124	984350	9
52	944758	950335	955622	960618	965321	969730	973844	977661	981181	984401	8
53	944854	950425	955707	960698	965397	969801	973910	977722	981237	984452	7
54	944949	950516	955793	960779	965473	969872	973976	977783	981293	984503	6
55	945044	950606	955879	960860	965548	969943	974042	977844	981349	984554	5
56	945139	950696	955964	960940	965624	970014	974108	977905	981405	984605	4
57	945234	950786	956049	961021	965700	970084	974173	977966	981460	984656	3
58	945329	950877	956134	961101	965775	970155	974239	978026	981516	984707	2
59	945424	950967	956220	961181	965850	970225	974305	978087	981572	984757	1
60	945519	951057	956305	961262	965926	970296	974370	978148	981627	984808	0
M	19°	18°	17°	16°	15°	14°	13°	12°	11°	10°	M

Natural Co-sines.

Diff. to 100″	162	154	146	138	130	121	113	105	97	88

M	80°	81°	82°	83°	84°	85°	86°	87°	88°	89°	M
0	984808	987688	990268	992546	994522	996195	997564	998630	999391	999848	60
1	984858	987734	990309	992582	994552	996220	997584	998645	999401	999853	59
2	984909	987779	990349	992617	994583	996245	997604	998660	999411	999858	58
3	984959	987824	990389	992652	994613	996270	997625	998675	999421	999863	57
4	985009	987870	990429	992687	994643	996295	997645	998690	999431	999867	56
5	985059	987915	990469	992722	994673	996320	997664	998705	999441	999872	55
6	985109	987960	990509	992757	994703	996345	997684	998719	999450	999877	54
7	985159	988005	990549	992792	994733	996370	997704	998734	999460	999881	53
8	985209	988050	990589	992827	994762	996395	997724	998749	999469	999886	52
9	985259	988094	990629	992862	994792	996419	997743	998763	999479	999890	51
10	985309	988139	990669	992896	994822	996444	997763	998778	999488	999894	50
11	985358	988184	990708	992931	994851	996468	997782	998792	999497	999898	49
12	985408	988228	990748	992966	994881	996493	997801	998806	999507	999903	48
13	985457	988273	990787	993000	994910	996517	997821	998820	999516	999907	47
14	985507	988317	990827	993034	994939	996541	997840	998834	999525	999910	46
15	985556	988362	990866	993068	994969	996566	997859	998848	999534	999914	45
16	985605	988406	990905	993103	994998	996589	997878	998862	999542	999918	44
17	985654	988450	990944	993137	995027	996614	997897	998876	999551	999922	43
18	985703	988494	990983	993171	995056	996637	997916	998890	999560	999925	42
19	985752	988538	991022	993205	995084	996661	997934	998904	999568	999929	41
20	985801	988582	991061	993238	995113	996685	997953	998917	999577	999932	40
21	985850	988626	991100	993272	995142	996709	997972	998931	999585	999936	39
22	985899	988669	991138	993306	995170	996732	997990	998944	999594	999939	38
23	985947	988713	991177	993339	995199	996756	998008	998957	999602	999942	37
24	985996	988756	991216	993373	995227	996779	998027	998971	999610	999945	36
25	986045	988800	991254	993406	995256	996802	998045	998984	999618	999948	35
26	986093	988843	991292	993439	995284	996825	998063	998997	999626	999951	34
27	986141	988886	991331	993473	995312	996848	998081	999010	999634	999954	33
28	986189	988930	991369	993506	995340	996872	998099	999023	999642	999957	32
29	986238	988973	991407	993539	995368	996894	998117	999035	999650	999959	31
30	986286	989016	991445	993572	995396	996917	998135	999048	999657	999962	30
31	986334	989059	991483	993605	995424	996940	998153	999061	999665	999964	29
32	986381	989102	991521	993638	995452	996963	998170	999073	999672	999967	28
33	986429	989145	991558	993670	995479	996985	998188	999086	999680	999969	27
34	986477	989187	991596	993703	995507	997008	998205	999098	999687	999971	26
35	986525	989230	991634	993735	995535	997030	998223	999111	999694	999974	25
36	986572	989272	991671	993768	995562	997053	998240	999123	999701	999976	24
37	986620	989315	991709	993800	995589	997075	995257	999135	999709	999978	23
38	986667	989357	991746	993833	995617	997097	998274	999147	999716	999980	22
39	986714	989399	991783	993865	995644	997119	998291	999159	999722	999981	21
40	986762	989442	991820	993897	995671	997141	998308	999171	999729	999983	20
41	986809	989484	991857	993929	995698	997163	998325	999183	999736	999985	19
42	986856	989526	991894	993961	995725	997185	998342	999194	999743	999986	18
43	986903	989568	991931	993993	995752	997207	998359	999206	999749	999988	17
44	986950	989610	991968	994025	995778	997229	998375	999218	999756	999989	16
45	986996	989651	992005	994056	995805	997250	998392	999229	999762	999990	15
46	987043	989693	992042	994088	995832	997272	998408	999240	999768	999992	14
47	987090	989735	992078	994120	995858	997293	998425	999252	999775	999993	13
48	987136	989776	992115	994151	995884	997314	998441	999263	999781	999994	12
49	987183	989818	992151	994182	995911	997336	998457	999274	999787	999995	11
50	987229	989859	992187	994214	995937	997357	998473	999285	999793	999996	10
51	987275	989900	992224	994245	995963	997378	998489	999296	999799	999997	9
52	987322	989942	992260	994276	995989	997399	998505	999307	999804	999997	8
53	987368	989983	992296	994307	996015	997420	998521	999318	999810	999998	7
54	987414	990024	992332	994338	996041	997441	998537	999328	999816	999998	6
55	987460	990065	992368	994369	996067	997462	998552	999339	999821	999999	5
56	987506	990105	992404	994400	996093	997482	998568	999350	999827	999999	4
57	987551	990146	992439	994430	996118	997503	998583	999360	999832	1000000	3
58	987597	990187	992475	994461	996144	997523	998599	999370	999837	1000000	2
59	987643	990228	992511	994491	996169	997544	998614	999381	999843	1000000	1
60	987688	990268	992546	994522	996105	997564	998630	999391	999848	1000000	0
M	9°	8°	7°	6°	5°	4°	3°	2°	1°	0°	M

Natural Co-sines.

Diff. to 100″	80	72	63	55	47	38	30	21	13	4

TABLE IV.

THE

ANGLES

Which every Point and Quarter Point of the Compass makes with the Meridian.

NORTH		POINTS	°	′	″	POINTS	SOUTH	
		0¼	2	48	45	0¼		
		0½	5	37	30	0½		
		0¾	8	26	15	0¾		
N. b. E.	N. b. W.	1	11	15	0	1	S. b. E.	S. b. W.
		1¼	14	3	45	1¼		
		1½	16	52	30	1½		
		1¾	19	41	15	1¾		
N. N. E.	N. N. W.	2	22	30	0	2	S. S. E.	S. S. W.
		2¼	25	18	45	2¼		
		2½	28	7	30	2½		
		2¾	30	56	15	2¾		
N.E.b.N.	N.W.b.N.	3	33	45	0	3	S. E. b. S.	S. W. b. S.
		3¼	36	33	45	3¼		
		3½	39	22	30	3½		
		3¾	42	11	15	3¾		
N. E.	N. W.	4	45	0	0	4	S. E.	S. W.
		4¼	47	48	45	4¼		
		4½	50	37	30	4½		
		4¾	53	26	15	4¾		
N.E.b.E.	N.W.bW.	5	56	15	0	5	S. E. b. E.	S.W.b.W
		5¼	59	3	45	5¼		
		5½	61	52	30	5½		
		5¾	64	41	15	5¾		
E. N. E.	W. N. W.	6	67	30	0	6	E. S. E.	W. S. W.
		6¼	70	18	45	6¼		
		6½	73	7	30	6½		
		6¾	75	56	15	6¾		
E. b. N.	W. b. N.	7	78	45	0	7	E. b. S.	W. b. S.
		7¼	81	33	45	7¼		
		7½	84	22	30	7½		
		7¾	87	11	15	7¾		
East.	West.	8	90	0	0	8	East.	West.

TABLE V.

A TRAVERSE TABLE,

To every Degree and Quarter Degree of the Compass or Horizon.

EXPLANATION.

This Table is calculated for the easy and expeditious solution of the several cases of Right-angled Plane Trigonometry. It is generally esteemed a useful and requisite assistant to the Surveyor, the Navigator, and to every one, who has any concern with trigonometry in the exercise of his profession. The manner of using it must be very obvious to all, who are acquainted with the principles of that excellent branch of geometry; but to those, who have only a superficial knowledge of the subject, the following description and examples will be necessary.

In this Table, one of the acute angles—whether given, or required—if less than 45°, is found, to the nearest 15′ at the top of the page; but, if more than 45°, it must be sought at the bottom, where the numbers are found in a retrograde order. And whether the angle under consideration, be at the top, or bottom, the Hypothenuse, if less than 120, is always in a *Distance* column; against which, in a column marked *Latitude*, is found the side contiguous to the angle; and in a column, marked *Departure*, the side opposite the angle.

When the given numbers exceed the limits of the table, any aliquot parts, such as a half, one third, &c. may be taken; and those found corresponding are to be doubled, trebled &c. that is, multiplied by the same figure, that the given number is divided by.

EXAMPLES.

1. Let the Hypothenuse of a right angled triangle=96 and one of the acute angles=33° 45′; required the sides.

Under 33° 45′ at the top of the table, and against 96 in a Distance column, are found 79.84 in a Latitude column for the side contiguous to the given angle, and 53.34 in a Departure column for the side opposite the given angle.

2. Let the sides of a right angled triangle be=89.23 and 66.02; required the angles and Hypothenuse.

By inspecting this table, till these two sides are found against each other in adjoining columns of Latitude and Departure, the angle opposite the longest side is found to be 53° 30′, the other, 36° 30′ and the Hypothenuse, 111.

In this manner all the cases of Right-angled Plane Trigonometry can be readily solved; but for more particular directions, books on this subject should be consulted.

Dist.	15′ Lat.	15′ Dep.	Dist.	30′ Lat.	30′ Dep.	Dist.	45′ Lat.	45′ Dep.
1	1.00	0.00	1	1.00	0.01	1	1.00	0.01
2	2.00	0.01	2	2.00	0.02	2	2.00	0.03
3	3.00	0.01	3	3.00	0.03	3	3.00	0.04
4	4.00	0.02	4	4.00	0.03	4	4.00	0.05
5	5.00	0.02	5	5.00	0.04	5	5.00	0.07
6	6.00	0.03	6	6.00	0.05	6	6.00	0.08
7	7.00	0.03	7	7.00	0.06	7	7.00	0.09
8	8.00	0.03	8	8.00	0.07	8	8.00	0.10
9	9.00	0.04	9	9.00	0.08	9	9.00	0.12
10	10.00	0.04	10	10.00	0.09	10	10.00	0.13
11	11.00	0.05	11	11.00	0.10	11	11.00	0.14
12	12.00	0.05	12	12.00	0.10	12	12.00	0.16
13	13.00	0.06	13	13.00	0.11	13	13.00	0.17
14	14.00	0.06	14	14.00	0.12	14	14.00	0.18
15	15.00	0.07	15	15.00	0.13	15	15.00	0.20
16	16.00	0.07	16	16.00	0.14	16	16.00	0.21
17	17.00	0.07	17	17.00	0.15	17	17.00	0.22
18	18.00	0.08	18	18.00	0.16	18	18.00	0.24
19	19.00	0.08	19	19.00	0.17	19	19.00	0.25
20	20.00	0.09	20	20.00	0.17	20	20.00	0.26
21	21.00	0.09	21	21.00	0.18	21	21.00	0.27
22	22.00	0.10	22	22.00	0.19	22	22.00	0.29
23	23.00	0.10	23	23.00	0.20	23	23.00	0.30
24	24.00	0.10	24	24.00	0.21	24	24.00	0.31
25	25.00	0.11	25	25.00	0.22	25	25.00	0.33
26	26.00	0.11	26	26.00	0.23	26	26.00	0.34
27	27.00	0.12	27	27.00	0.24	27	27.00	0.35
28	28.00	0.12	28	28.00	0.24	28	28.00	0.37
29	29.00	0.13	29	29.00	0.25	29	29.00	0.38
30	30.00	0.13	30	30.00	0.26	30	30.00	0.39
31	31.00	0.14	31	31.00	0.27	31	31.00	0.41
32	32.00	0.14	32	32.00	0.28	32	32.00	0.42
33	33.00	0.14	33	33.00	0.29	33	33.00	0.43
34	34.00	0.15	34	34.00	0.30	34	34.00	0.44
35	35.00	0.15	35	35.00	0.31	35	35.00	0.46
36	36.00	0.16	36	36.00	0.31	36	36.00	0.47
37	37.00	0.16	37	37.00	0.32	37	37.00	0.48
38	38.00	0.17	38	38.00	0.33	38	38.00	0.50
39	39.00	0.17	39	39.00	0.34	39	39.00	0.51
40	40.00	0.17	40	40.00	0.35	40	40.00	0.52
41	41.00	0.18	41	41.00	0.36	41	41.00	0.54
42	42.00	0.18	42	42.00	0.37	42	42.00	0.55
43	43.00	0.19	43	43.00	0.38	43	43.00	0.56
44	44.00	0.19	44	44.00	0.38	44	44.00	0.58
45	45.00	0.20	45	45.00	0.39	45	45.00	0.59
46	46.00	0.20	46	46.00	0.40	46	46.00	0.60
47	47.00	0.21	47	47.00	0.41	47	47.00	0.62
48	48.00	0.21	48	48.00	0.42	48	48.00	0.63
49	49.00	0.21	49	49.00	0.43	49	49.00	0.64
50	50.00	0.22	50	50.00	0.44	50	50.00	0.65
51	51.00	0.22	51	51.00	0.45	51	51.00	0.67
52	52.00	0.23	52	52.06	0.45	52	52.00	0.68
53	53.00	0.23	53	53.00	0.46	53	53.00	0.99
54	54.00	0.24	54	54.00	0.47	54	54.00	0.71
55	55.00	0.24	55	55.00	0.48	55	55.00	0.72
56	56.00	0.24	56	56.00	0.49	56	56.00	0.73
57	57.00	0.25	57	57.00	0.50	57	57.00	0.75
58	58.00	0.25	58	58.00	0.51	58	57.99	0.76
59	59.00	0.25	59	59.00	0.51	59	58.99	0.77
60	60.00	0.26	60	60.00	0.52	60	59.99	0.79
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.
	45′			30′			15′	

Dist.	15′ Lat.	15′ Dep.	Dist.	30′ Lat.	30′ Dep.	Dist.	45′ Lat.	45′ Dep.
61	61.00	0.27	61	61.00	0.53	61	60.99	0.80
62	62.00	0.27	62	62.00	0.54	62	61.99	0.81
63	63.00	0.27	63	63.00	0.55	63	62.99	0.82
64	64.00	0.28	64	64.00	0.56	64	63.99	0.84
65	65.00	0.28	65	65.00	0.57	65	64.99	0.85
66	66.00	0.29	66	66.00	0.58	66	65.99	0.86
67	67.00	0.29	67	67.00	0.58	67	66.99	0.88
68	68.00	0.30	68	68.00	0.59	68	67.99	0.89
69	69.00	0.30	69	69.00	0.60	69	68.99	0.92
70	70.00	0.31	70	70.00	0.61	70	69.99	0.92
71	71.00	0.31	71	71.00	0.62	71	70.99	0.93
72	72.00	0.31	72	72.00	0.63	72	71.99	0.94
73	73.00	0.32	73	73.00	0.64	73	72.99	0.96
74	74.00	0.32	74	74.00	0.65	74	73.99	0.97
75	75.00	1.33	75	75.00	0.65	75	74.99	0.98
76	76.00	0.33	76	76.00	0.66	76	75.99	0.99
77	77.00	0.34	77	77.00	0.67	77	76.99	1.01
78	78.00	0.34	78	78.00	0.68	78	77.99	1.02
79	79.00	0.34	79	79.00	0.69	79	78.99	1.03
80	80.00	0.35	80	80.00	0.70	80	79.99	1.05
81	81.00	0.35	81	81.00	0.71	81	80.99	1.06
82	82.00	0.36	82	82.00	0.72	82	81.99	1.07
83	83.00	0.36	83	83.00	0.72	83	82.99	1.09
84	84.00	0.37	84	84.00	0.73	84	83.99	1.10
85	85.00	0.37	85	85.00	0.74	85	84.99	1.11
86	86.00	0.38	86	86.00	0.75	86	85.99	1.13
87	87.00	0.38	87	87.00	0.76	87	86.99	1.14
88	88.00	0.38	88	88.00	0.77	88	87.99	1.15
89	89.00	0.39	89	89.00	0.78	89	88.99	1.16
90	90.00	0.39	90	90.00	0.79	90	89.99	1.18
91	91.00	0.40	91	91.00	0.79	91	90.99	1.19
92	92.00	0.40	92	92.00	0.80	92	91.99	1.20
93	93.00	0.41	93	93.00	0.81	93	92.99	1.22
94	94.00	0.41	94	94.00	0.82	94	93.99	1.23
95	95.00	0.41	95	95.00	0.83	95	94.99	1.24
96	96.00	0.42	96	96.00	0.84	96	95.99	1.26
97	97.00	0.42	97	97.00	0.85	97	96.99	1.27
98	98.00	0.43	98	98.00	0.86	98	97.99	1.28
99	99.00	0.43	99	99.00	0.86	99	98.99	1.30
100	100.0	0.44	100	100.0	0.87	100	99.99	1.31
101	101.0	0.44	101	101.0	0.88	101	101.0	1.32
102	102.0	0.45	102	102.0	0.89	102	102.0	1.34
103	103.0	0.45	103	103.0	0.90	103	103.0	1.35
104	104.0	0.45	104	104.0	0.91	104	104.0	1.36
105	105.0	0.46	105	105.0	0.92	105	105.0	1.37
106	106.0	0.46	106	106.0	0.92	106	106.0	1.39
107	107.0	0.47	107	107.0	0.93	107	107.0	1.40
108	108.0	0.47	108	108.0	0.94	108	108.0	1.41
109	109.0	0.48	109	109.0	0.95	109	109.0	1.43
110	110.0	0.48	110	110.0	0.96	110	110.0	1.44
111	111.0	0.48	111	111.0	0.97	111	111.0	1.45
112	112.0	0.49	112	112.0	0.98	112	112.0	1.47
113	113.0	0.49	113	113.0	0.99	113	113.0	1.48
114	114.0	0.50	114	114.0	0.99	114	114.0	1.49
115	115.0	0.50	115	115.0	1.00	115	115.0	1.51
116	116.0	0.51	116	116.0	1.01	116	116.0	1.52
117	117.0	0.51	117	117.0	1.02	117	117.0	1.53
118	118.0	0.51	118	118.0	1.03	118	118.0	1.54
119	119.0	0.52	119	119.0	1.04	119	119.0	1.56
120	120.0	0.52	120	120.0	1.05	120	120.0	1.57
Dist.	45′ Dep.	45′ Lat.	Dist.	30′ Dep.	30′ Lat.	Dist.	15′ Dep.	15′ Lat.

Dist.	0' Lat.	0' Dep.	15' Lat.	15' Dep.	30' Lat.	30' Dep.	45' Lat.	45' Dep.
1	1.00	0.02	1.00	0.02	1.00	0.03	1.00	0.03
2	2.00	0.03	2.00	0.04	2.00	0.05	2.00	0.06
3	3.00	0.05	3.00	0.07	3.00	0.08	3.00	0.09
4	4.00	0.07	4.00	0.09	4.00	0.10	4.00	0.12
5	5.00	0.09	5.00	0.11	5.00	0.13	5.00	0.15
6	6.00	0.10	6.00	0.13	6.00	0.16	6.00	0.18
7	7.00	0.12	7.00	0.15	7.00	0.18	7.00	0.21
8	8.00	0.14	8.00	0.17	8.00	0.21	8.00	0.24
9	9.00	0.16	9.00	0.20	9.00	0.24	9.00	0.27
10	10.00	0.17	10.00	0.22	10.00	0.26	10.00	0.31
11	11.00	0.19	11.00	0.24	11.00	0.29	10.99	0.34
12	12.00	0.21	12.00	0.26	12.00	0.31	11.99	0.37
13	13.00	0.23	13.00	0.28	13.00	0.34	12.99	0.40
14	14.00	0.24	14.00	0.31	14.00	0.37	13.99	0.43
15	15.00	0.26	15.00	0.33	14.99	0.39	14.99	0.46
16	16.00	0.28	16.00	0.35	15.99	0.42	15.99	0.49
17	17.00	0.30	17.00	0.37	16.99	0.45	16.99	0.52
18	18.00	0.31	18.00	0.39	17.99	0.47	17.99	0.55
19	19.00	0.33	19.00	0.41	18.99	0.50	18.99	0.58
20	20.00	0.35	20.00	0.44	19.99	0.52	19.99	0.61
21	21.00	0.37	21.00	0.46	20.99	0.55	20.99	0.64
22	22.00	0.38	21.99	0.48	21.99	0.58	21.99	0.67
23	23.00	0.40	22.99	0.50	22.99	0.60	22.99	0.70
24	24.00	0.42	23.99	0.52	23.99	0.63	23.99	0.73
25	25.00	0.44	24.99	0.55	24.99	0.65	24.99	0.76
26	26.00	0.45	25.99	0.57	25.99	0.68	25.99	0.79
27	27.00	0.47	26.99	0.59	26.99	0.71	26.99	0.82
28	28.00	0.49	27.99	0.61	27.99	0.73	27.99	0.86
29	29.00	0.51	28.99	0.63	28.99	0.76	28.99	0.89
30	30.00	0.52	29.99	0.65	29.99	0.79	29.99	0.92
31	31.00	0.54	30.99	0.68	30.99	0.81	30.99	0.95
32	32.00	0.56	31.99	0.70	31.99	0.84	31.99	0.98
33	33.00	0.58	32.99	0.72	32.99	0.86	32.98	1.01
34	33.99	0.59	33.99	0.74	33.99	0.89	33.98	1.04
35	34.99	0.61	34.99	0.76	34.99	0.92	34.98	1.07
36	35.99	0.63	35.99	0.79	35.99	0.94	35.98	1.10
37	36.99	0.65	36.99	0.81	36.99	0.97	36.98	1.13
38	37.99	0.66	37.99	0.83	37.99	0.99	37.98	1.16
39	38.99	0.68	38.99	0.85	38.99	1.02	38.98	1.19
40	39.99	0.70	39.99	0.87	39.99	1.05	39.98	1.22
41	40.99	0.72	40.99	0.89	40.99	1.07	40.98	1.25
42	41.99	0.73	41.99	0.92	41.99	1.10	41.98	1.28
43	42.99	0.75	42.99	0.94	42.99	1.13	42.98	1.31
44	43.99	0.77	43.99	0.96	43.98	1.15	43.98	1.34
45	44.99	0.79	44.99	0.98	44.98	1.18	44.98	1.37
46	45.99	0.80	45.99	1.00	45.98	1.20	45.98	1.40
47	46.99	0.82	46.99	1.03	46.98	1.23	46.98	1.44
48	47.99	0.84	47.99	1.05	47.98	1.26	47.98	1.47
49	48.99	0.85	48.99	1.07	48.98	1.28	48.98	1.50
50	49.99	0.87	49.99	1.09	49.98	1.31	49.98	1.53
51	50.99	0.89	50.99	1.11	50.98	1.34	50.98	1.56
52	51.99	0.91	51.99	1.13	51.98	1.36	51.98	1.59
53	52.99	0.93	52.99	1.16	52.98	1.39	52.98	1.62
54	53.99	0.94	53.99	1.18	53.98	1.41	53.97	1.65
55	54.99	0.96	54.99	1.20	54.98	1.44	54.97	1.68
56	55.99	0.98	55.99	1.22	55.98	1.47	55.97	1.71
57	56.99	0.99	56.99	1.24	56.98	1.49	56.97	1.74
58	57.99	1.01	57.99	1.27	57.98	1.52	57.97	1.77
59	58.99	1.03	58.99	1.29	58.98	1.54	58.97	1.80
60	59.99	1.05	59.99	1.31	59.98	1.57	59.97	1.83
Dist.	Dep.	Lat.	Dep.	Lat	Dep.	Lat.	Dep.	Lat
	0'		45'		30'		15'	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
61	60.99	1.06	60.99	1.33	60.98	1.60	60.97	1.86
62	61.99	1.08	61.99	1.35	61.98	1.62	61.97	1.89
63	62.99	1.10	62.98	1.37	62.98	1.65	62.97	1.92
64	63.99	1.12	63.98	1.40	63.98	1.68	63.97	1.95
65	64.99	1.13	64.98	1.42	64.98	1.70	64.97	1.99
66	65.99	1.15	65.98	1.44	65.98	1.73	65.97	2.02
67	66.99	1.17	66.98	1.46	66.98	1.75	66.97	2.05
68	67.99	1.19	67.98	1.48	67.98	1.78	67.97	2.08
69	68.99	1.20	68.98	1.51	68.98	1.81	68.97	2.11
70	69.99	1.22	69.98	1.53	69.98	1.83	69.97	2.14
71	70.99	1.24	70.98	1.55	70.98	1.86	70.97	2.17
72	71.99	1.26	71.98	1.57	71.98	1.88	71.97	2.20
73	72.99	1.27	72.98	1.59	72.98	1.91	72.97	2.23
74	73.99	1.29	73.98	1.61	73.97	1.94	73.97	2.26
75	74.99	1.31	74.98	1.64	74.97	1.96	74.97	2.29
76	75.99	1.33	75.98	1.66	75.97	1.99	75.96	2.32
77	76.99	1.34	76.98	1.68	76.97	2.02	76.96	2.35
78	77.99	1.36	77.98	1.70	77.97	2.04	77.96	2.38
79	78.99	1.38	78.98	1.72	78.97	2.07	78.96	2.41
80	79.99	1.40	79.98	1.75	79.97	2.09	79.96	2.44
81	80.99	1.41	80.98	1.77	80.97	2.12	80.96	2.47
82	81.99	1.43	81.98	1.79	81.97	2.15	81.96	2.50
83	82.99	1.45	82.98	1.81	82.97	2.17	82.96	2.53
84	83.99	1.47	83.98	1.83	83.97	2.20	83.96	2.57
85	84.99	1.48	84.98	1.85	84.97	2.23	84.96	2.60
86	85.99	1.50	85.98	1.88	85.97	2.25	85.96	2.63
87	86.99	1.52	86.98	1.90	86.97	2.28	86.96	2.66
88	87.99	1.54	87.98	1.92	87.97	2.30	87.96	2.69
89	88.99	1.55	88.98	1.94	88.97	2.33	88.96	2.72
90	89.99	1.57	89.98	1.96	89.97	2.36	89.96	2.75
91	90.99	1.59	90.98	1.99	90.97	2.38	90.96	2.78
92	91.99	1.61	91.98	2.01	91.97	2.41	91.96	2.81
93	92.99	1.62	92.98	2.03	92.97	2.43	92.96	2.84
94	93.99	1.64	93.98	2.05	93.97	2.46	93.96	2.87
95	94.99	1.66	94.98	2.07	94.97	2.49	94.96	2.90
96	95.99	1.68	95.98	2.09	95.97	2.51	95.96	2.93
97	96.99	1.69	96.98	2.12	96.97	2.54	96.95	2.96
98	97.99	1.71	97.98	2.14	97.97	2.57	97.95	2.99
99	98.98	1.73	98.98	2.16	98.97	2.59	98.95	3.02
100	99.98	1.75	99.98	2.18	99.97	2.62	99.95	3.05
101	101.0	1.76	101.0	2.20	101.0	2.64	101.0	3.08
102	102.0	1.78	102.0	2.23	102.0	2.67	102.0	3.12
103	103.0	1.80	103.0	2.25	103.0	2.70	103.0	3.15
104	104.0	1.82	104.0	2.27	104.0	2.72	104.0	3.18
105	105.0	1.83	105.0	2.29	105.0	2.75	105.0	3.21
106	106.0	1.85	106.0	2.31	106.0	2.77	106.0	3.24
107	107.0	1.87	107.0	2.33	107.0	2.80	107.0	3.27
108	108.0	1.88	108.0	2.36	108.0	2.83	108.0	3.30
109	109.0	1.90	109.0	2.38	109.0	2.85	109.0	3.33
110	110.0	1.92	110.0	2.40	110.0	2.88	110.0	3.36
111	111.0	1.94	111.0	2.42	111.0	2.91	111.0	3.39
112	112.0	1.95	112.0	2.44	112.0	2.93	112.0	3.42
113	113.0	1.97	113.0	2.47	113.0	2.96	113.0	3.45
114	114.0	1.99	114.0	2.49	114.0	2.98	114.0	3.48
115	115.0	2.01	115.0	2.51	115.0	3.01	115.0	3.51
116	116.0	2.02	116.0	2.53	116.0	3.04	116.0	3.54
117	117.0	2.04	117.0	2.55	117.0	3.06	117.0	3.57
118	118.0	2.06	118.0	2.57	118.0	3.09	118.0	3.60
119	119.0	2.08	119.0	2.60	119.0	3.12	119.0	3.63
120	120.0	2.09	120.0	2.62	120.0	3.14	120.0	3.66
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
1	1.00	0.03	1.00	0.04	1.00	0.04	1.00	0.05
2	2.00	0.07	2.00	0.08	2.00	0.09	2.00	0.10
3	3.00	0.10	3.00	0.12	3.00	0.13	3.00	0.14
4	4.00	0.14	4.00	0.16	3.99	0.17	4.00	0.19
5	5.00	0.17	5.00	0.20	5.00	0.22	4.99	0.24
6	6.00	0.21	6.00	0.24	5.99	0.26	5.99	0.29
7	7.00	0.24	6.99	0.27	6.99	0.31	6.99	0.34
8	8.00	0.28	7.99	0.31	7.99	0.35	7.99	0.38
9	8.99	0.31	8.99	0.35	8.99	0.39	8.99	0.43
10	9.99	0.35	9.99	0.39	9.99	0.44	9.99	0.48
11	10.99	0.38	10.99	0.43	10.99	0.48	10.99	0.53
12	11.99	0.42	11.99	0.47	11.99	0.52	11.99	0.58
13	12.99	0.45	12.99	0.51	12.99	0.57	12.99	0.62
14	13.99	0.49	13.99	0.55	13.99	0.61	13.98	0.67
15	14.99	0.52	14.99	0.59	14.99	0.65	14.98	0.72
16	15.99	0.56	15.99	0.63	15.98	0.70	15.98	0.77
17	16.99	0.59	16.99	0.67	16.98	0.74	16.98	0.82
18	17.99	0.63	17.99	0.71	17.98	0.79	17.98	0.86
19	18.99	0.66	18.99	0.75	18.98	0.83	18.98	0.91
20	19.99	0.70	19.98	0.79	19.98	0.87	19.98	0.96
21	20.99	0.73	20.98	0.82	20.98	0.92	20.98	1.01
22	21.99	0.77	21.98	0.86	21.98	0.96	21.97	1.06
23	22.99	0.80	22.98	0.90	22.98	1.00	22.97	1.10
24	23.99	0.84	23.98	0.94	23.98	1.05	23.97	1.15
25	24.98	0.87	24.98	0.98	24.98	1.09	24.97	1.20
26	25.98	0.91	25.98	1.02	25.98	1.13	25.97	1.25
27	26.98	0.94	26.98	1.06	26.97	1.18	26.97	1.30
28	27.98	0.98	27.98	1.10	27.97	1.22	27.97	1.34
29	28.98	1.01	28.98	1.14	28.97	1.27	28.97	1.39
30	29.98	1.05	29.98	1.18	29.97	1.31	29.97	1.44
31	30.98	1.08	30.98	1.22	30.97	1.35	30.96	1.49
32	31.98	1.12	31.98	1.26	31.97	1.40	31.96	1.54
33	32.98	1.15	32.97	1.30	32.97	1.44	32.96	1.58
34	33.98	1.19	33.97	1.33	33.97	1.48	33.96	1.63
35	34.98	1.22	34.97	1.37	34.97	1.53	34.96	1.68
36	35.98	1.26	35.97	1.41	35.97	1.57	35.96	1.73
37	36.98	1.29	36.97	1.45	36.96	1.61	36.96	1.78
38	37.98	1.33	37.97	1.49	37.96	1.66	37.96	1.82
39	38.98	1.36	38.97	1.53	38.96	1.70	38.96	1.87
40	39.98	1.40	39.97	1.57	39.96	1.74	39.95	1.92
41	40.98	1.43	40.97	1.61	40.96	1.79	40.95	1.97
42	41.97	1.47	41.97	1.65	41.96	1.83	41.95	2.02
43	42.97	1.50	42.97	1.69	42.96	1.88	42.95	2.06
44	43.97	1.54	43.97	1.73	43.96	1.92	43.95	2.11
45	44.97	1.57	44.97	1.77	44.96	1.96	44.95	2.16
46	45.97	1.61	45.96	1.81	45.96	2.01	45.95	2.21
47	46.97	1.64	46.96	1.85	46.96	2.05	46.95	2.26
48	47.97	1.68	47.96	1.88	47.95	2.09	47.94	2.30
49	48.97	1.71	48.96	1.92	48.95	2.14	48.94	2.35
50	49.97	1.75	49.96	1.96	49.95	2.18	49.94	2.40
51	50.97	1.78	50.96	2.00	50.95	2.22	50.94	2.45
52	51.97	1.81	51.96	2.04	51.95	2.27	51.94	2.49
53	52.97	1.85	52.96	2.08	52.95	2.31	52.94	2.54
54	53.97	1.88	53.96	2.12	53.95	2.36	53.94	2.59
55	54.97	1.92	54.96	2.16	54.95	2.40	54.94	2.64
56	55.97	1.95	55.96	2.20	55.95	2.44	55.94	2.69
57	56.97	1.99	56.96	2.24	56.95	2.49	56.93	2.73
58	57.96	2.02	57.96	2.28	57.94	2.53	57.93	2.78
59	58.96	2.06	58.96	2.32	58.94	2.57	58.93	2.83
60	59.96	2.09	59.96	3.36	59.94	2.62	59.93	2.88
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep.	15′ Lat	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
61	60.96	2.13	60.95	2.39	60.94	2.66	60.93	2.93
62	61.96	2.16	61.95	2.43	61.94	2.70	61.93	2.97
63	62.96	2.20	62.95	2.47	62.94	2.75	62.93	3.02
64	63.96	2.23	63.95	2.51	63.94	2.79	63.93	3.07
65	64.96	2.27	64.95	2.55	64.94	2.84	64.93	3.12
66	65.96	2.30	65.95	2.59	65.94	2.88	65.92	3.17
67	66.96	2.34	66.95	2.63	66.94	2.92	66.92	3.21
68	67.96	2.37	67.95	2.67	67.94	2.97	67.92	3.26
69	68.96	2.41	68.95	2.71	68.93	3.01	68.92	3.31
70	69.96	2.44	69.95	2.75	69.93	3.05	69.92	3.36
71	70.96	2.48	70.95	2.79	70.93	3.10	70.92	3.41
72	71.96	2.51	71.94	2.83	71.93	3.14	71.92	3.45
73	72.96	2.55	72.94	2.87	72.93	3.18	72.92	3.50
74	73.95	2.58	73.94	2.91	73.93	3.23	73.91	3.55
75	74.95	2.62	74.94	2.94	74.93	3.27	74.91	3.60
76	75.95	2.65	75.94	2.98	75.93	3.32	75.91	3.65
77	76.95	2.69	76.94	3.02	76.93	3.36	76.91	3.69
78	77.95	2.72	77.94	3.06	77.93	3.40	77.91	3.74
79	78.95	2.76	78.94	3.10	78.92	3.45	78.91	3.79
80	79.95	2.79	79.94	3.14	79.92	3.49	79.91	3.84
81	80.95	2.83	80.94	3.18	80.92	3.53	80.91	3.89
82	81.95	2.86	81.94	3.22	81.92	3.58	81.91	3.93
83	82.95	2.90	82.94	3.26	82.92	3.62	82.90	3.98
84	83.95	2.93	83.94	3.30	83.92	3.66	83.90	4.03
85	84.95	2.97	84.93	3.34	84.92	3.71	84.90	4.08
86	85.95	3.00	85.93	3.38	85.92	3.75	85.90	4.13
87	86.95	3.04	86.93	3.42	86.92	3.79	86.90	4.17
88	87.95	3.07	87.93	3.45	87.92	3.84	87.90	4.22
89	88.95	3.11	88.93	3.49	88.92	3.88	88.90	4.27
90	89.95	3.14	89.93	3.53	89.91	3.93	89.90	4.32
91	90.94	3.18	90.93	3.57	90.91	3.97	90.90	4.37
92	91.94	3.21	91.93	3.61	91.91	4.01	91.89	4.41
93	92.94	3.25	92.93	3.65	92.91	4.06	92.89	4.46
94	93.94	3.28	93.93	3.69	93.91	4.10	93.89	4.51
95	94.94	3.32	94.93	3.73	94.91	4.14	94.89	4.56
96	95.94	3.35	95.93	3.77	95.91	4.19	95.89	4.61
97	96.94	3.39	96.93	3.81	96.91	4.23	96.89	4.65
98	97.94	3.42	97.92	3.85	97.91	4.27	97.89	4.70
99	98.94	3.46	98.92	3.89	98.91	4.32	98.89	4.75
100	99.94	3.49	99.92	3.93	99.90	4.36	99.88	4.80
101	100.9	3.53	100.9	3.96	100.9	4.41	100.9	4.85
102	101.9	3.56	101.9	4.00	101.9	4.45	101.9	4.89
103	102.9	3.59	102.9	4.04	102.9	4.49	102.9	4.94
104	103.9	3.63	103.9	4.08	103.9	4.54	103.9	4.99
105	104.9	3.66	104.9	4.12	104.9	4.58	104.9	5.04
106	105.9	3.70	105.9	4.16	105.9	4.62	105.9	5.09
107	106.9	3.73	106.9	4.20	106.9	4.67	106.9	5.13
108	107.9	3.77	107.9	4.24	107.9	4.71	107.9	5.18
109	108.9	3.80	108.9	4.28	108.9	4.75	108.9	5.23
110	109.9	3.84	109.9	4.32	109.9	4.80	109.9	5.28
111	110.9	3.87	110.9	4.36	110.9	4.84	110.9	5.33
112	111.9	3.91	111.9	4.40	111.9	4.89	111.9	5.37
113	112.9	3.94	112.9	4.44	112.9	4.93	112.9	5.42
114	113.9	3.98	113.9	4.48	113.9	4.97	113.9	5.47
115	114.9	4.01	114.9	4.51	114.9	5.02	114.9	5.52
116	115.9	4.05	115.9	4.55	115.9	5.06	115.9	5.57
117	116.9	4.08	116.9	4.59	116.9	5.10	116.9	5.61
118	117.9	4.12	117.9	4.63	117.9	5.15	117.9	5.66
119	118.9	4.15	118.9	4.67	118.9	5.19	118.9	5.71
120	119.9	4.19	119.9	4.71	119.9	5.23	119.9	5.76
Dist.	Dep	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0' Lat.	0' Dep.	15' Lat.	15' Dep.	30' Lat.	30' Dep.	45' Lat.	45' Dep.
1	1.00	0.05	1.00	0.06	1.00	0.06	1.00	0.07
2	2.00	0.10	2.00	0.11	2.00	0.12	2.00	0.13
3	3.00	0.16	3.00	0.17	2.99	0.18	2.99	0.2[illegible]
4	3.99	0.21	4.00	0.23	3.99	0.24	3.99	0.2[illegible]
5	4.99	0.26	4.99	0.28	4.99	0.31	4.99	0.3[illegible]
6	5.99	0.31	5.99	0.34	5.99	0.37	5.99	0.39
7	6.99	0.37	6.99	0.40	6.99	0.43	6.99	0.45
8	7.99	0.42	7.99	0.45	7.99	0.49	7.98	0.52
9	8.99	0.47	8.99	0.51	8.98	0.55	8.98	0.59
10	9.99	0.52	9.98	0.57	9.98	0.61	9.98	0.65
11	10.98	0.58	10.98	0.62	10.98	0.67	10.98	0.72
12	11.98	0.63	11.98	0.68	11.98	0.73	11.97	0.78
13	12.98	0.68	12.98	0.74	12.98	0.79	12.97	0.85
14	13.98	0.73	13.98	0.79	13.97	0.85	13.97	0.92
15	14.98	0.79	14.98	0.85	14.97	0.92	14.97	0.98
16	15.98	0.84	15.97	0.91	15.97	0.98	15.97	1.05
17	16.98	0.89	16.97	0.96	16.97	1.04	16.96	1.11
18	17.98	0.94	17.97	1.02	17.97	1.10	17.96	1.18
19	18.97	0.99	18.97	1.08	18.96	1.16	18.96	1.24
20	19.97	1.05	19.97	1.13	19.96	1.22	19.96	1.31
21	20.97	1.10	20.97	1.19	20.96	1.28	20.96	1.67
22	21.97	1.15	21.97	1.25	21.96	1.34	21.95	1.44
23	22.97	1.20	22.96	1.30	22.96	1.40	22.95	1.50
24	23.97	1.26	23.96	1.36	23.96	1.47	23.95	1.57
25	24.97	1.31	24.96	1.42	24.95	1.53	24.95	1.64
26	25.96	1.36	25.96	1.47	25.95	1.59	25.94	1.70
27	26.96	1.41	26.96	1.53	26.95	1.65	26.94	1.77
28	27.96	1.47	27.96	1.59	27.95	1.71	27.94	1.83
29	28.96	1.52	28.95	1.64	28.95	1.77	28.94	1.90
30	29.96	1.57	29.95	1.70	29.94	1.83	29.94	1.96
31	30.96	1.62	30.95	1.76	30.94	1.89	30.93	2.03
32	31.96	1.67	31.95	1.81	31.94	1.95	31.93	2.09
33	32.95	1.73	32.95	1.87	32.94	2.01	32.93	2.16
34	33.95	1.78	33.95	1.93	33.94	2.08	33.93	2.22
35	34.95	1.83	34.94	1.98	34.93	2.14	34.93	2.29
36	35.95	1.88	35.94	2.04	35.93	2.20	35.92	2.35
37	36.95	1.94	36.94	2.10	36.93	2.26	36.92	2.42
38	37.95	1.99	37.94	2.15	37.93	2.32	37.92	2.49
39	38.95	2.04	38.94	2.21	38.93	2.38	38.92	2.55
40	39.95	2.09	39.94	2.27	39.93	2.44	39.91	2.62
41	40.94	2.15	40.93	2.32	40.92	2.50	40.91	2.68
42	41.94	2.20	41.93	2.38	41.92	2.56	41.91	2.75
43	42.94	2.25	42.93	2.44	42.92	2.63	42.91	2.81
44	43.94	2.30	43.93	2.49	43.92	2.69	43.91	2.88
45	44.94	2.36	44.93	2.55	44.92	2.75	44.90	2.94
46	45.94	2.41	45.93	2.61	45.91	2.81	45.90	3.01
47	46.94	2.46	46.92	2.66	46.91	2.87	46.90	3.07
48	47.93	2.51	47.92	2.72	47.91	2.93	47.90	3.14
49	48.93	2.56	48.92	2.78	48.91	2.99	48.90	3.20
50	49.93	2.62	49.92	2.83	49.91	3.05	49.89	3.27
51	50.93	2.67	50.92	2.89	50.90	3.11	50.89	3.34
52	51.93	2.72	51.92	2.95	51.90	3.17	51.89	3.40
53	52.93	2.77	52.91	3.00	52.90	3.24	52.89	3.47
54	53.93	2.83	53.91	3.06	53.90	3.30	53.88	3.53
55	54.92	2.88	54.91	3.12	54.90	3.36	54.88	3.60
56	55.92	2.93	55.91	3.17	55.90	3.42	55.88	3.66
57	56.92	2.98	56.91	3.23	56.89	3.48	56.88	3.73
58	57.92	3.04	57.91	3.29	57.89	3.54	57.88	3.79
59	58.92	3.09	58.91	3.34	58.89	3.60	58.87	3.86
60	59.92	3.14	59.90	3.40	59.89	3.66	59.87	3.92
Dist.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.
	0'		45'		30'		15'	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
61	60.92	3.19	60.90	3.46	60.89	3.72	60.87	3.99
62	61.92	3.24	61.90	3.52	61.88	3.79	61.87	4.06
63	62.91	3.30	62.90	3.57	62.88	3.85	62.87	4.12
64	63.91	3.35	63.90	3.63	63.88	3.91	63.86	4.19
65	64.91	3.40	64.90	3.69	64.88	3.97	64.86	4.25
66	65.91	3.45	65.89	3.74	65.88	4.03	65.86	4.32
67	66.91	3.51	66.89	3.80	66.88	4.09	66.86	4.38
68	67.91	3.56	67.89	3.86	67.87	4.15	67.85	4.45
69	68.91	3.61	68.89	3.91	68.87	4.21	68.85	4.51
70	69.90	3.66	69.89	3.97	69.87	4.27	69.85	4.58
71	70.90	3.72	70.89	4.03	70.87	4.33	70.85	4.64
72	71.90	3.77	71.88	4.08	71.87	4.40	71.85	4.71
73	72.90	3.82	72.88	4.14	72.86	4.46	72.84	4.77
74	73.90	3.87	73.88	4.20	73.86	4.52	73.84	4.84
75	74.90	3.93	74.88	4.25	74.86	4.58	74.84	4.91
76	75.90	3.98	75.88	4.31	75.86	4.64	75.84	4.97
77	76.89	4.03	76.88	4.37	76.86	4.70	76.84	5.04
78	77.89	4.08	77.87	4.42	77.85	4.76	77.83	5.10
79	78.89	4.13	78.87	4.48	78.85	4.82	78.83	5.17
80	79.89	4.19	79.87	4.54	79.85	4.88	79.83	5.23
81	80.89	4.24	80.87	4.59	80.85	4.94	80.83	5.30
82	81.89	4.29	81.87	4.65	81.85	5.01	81.82	5.36
83	82.89	4.34	82.87	4.71	82.85	5.07	82.82	5.43
84	83.88	4.40	83.86	4.76	83.84	5.13	83.82	5.49
85	84.88	4.45	84.86	4.82	84.84	5.19	84.82	5.56
86	85.88	4.50	85.86	4.88	85.84	5.25	85.82	5.62
87	86.88	4.55	86.86	4.93	86.84	5.31	86.81	5.69
88	87.88	4.61	87.86	4.99	87.84	5.37	87.81	5.76
89	88.88	4.66	88.86	5.05	88.83	5.43	88.81	5.82
90	89.88	4.71	89.86	5.10	89.83	5.49	89.81	5.89
91	90.88	4.76	90.85	5.16	90.83	5.56	90.81	5.95
92	91.87	4.81	91.85	5.22	91.83	5.62	91.80	6.02
93	92.87	4.87	92.85	5.27	92.83	5.68	92.80	6.08
94	93.87	4.92	93.85	5.33	93.82	5.74	93.80	6.15
95	94.87	4.97	94.85	5.39	94.82	5.80	94.80	6.21
96	95.87	5.02	95.85	5.44	95.82	5.86	95.79	6.28
97	96.87	5.08	96.84	5.50	96.82	5.92	96.79	6.34
98	97.87	5.13	97.84	5.56	97.82	5.[illegible]8	97.79	6.41
99	98.86	5.18	98.84	5.61	98.82	6.04	98.79	6.47
100	99.86	5.23	99.84	5.67	99.81	6.10	99.79	6.54
101	100.9	5.29	100.8	5.73	100.8	6.17	100.8	6.61
102	101.9	5.34	101.8	5.78	101.8	6.23	101.8	6.67
103	102.9	5.39	102.8	5.84	102.8	6.29	102.8	6.74
104	103.9	5.44	103.8	5.90	103.8	6.35	103.8	6.80
105	104.9	5.50	104.8	5.95	104.8	6.41	104.8	6.87
106	105.9	5.55	105.8	6.01	105.8	6.47	105.8	6.93
107	106.9	5.60	106.8	6.07	106.8	6.53	106.8	7.00
108	107.9	5.65	107.8	6.12	107.8	6.59	107.8	7.06
109	108.9	5.70	108.8	6.18	108.8	6.65	108.8	7.13
110	109.8	5.76	109.8	6.24	109.8	6.72	109.8	7.19
111	110.8	5.81	110.8	6.29	110.8	6.78	110.8	7.26
112	111.8	5.86	111.8	6.35	111.8	6.84	111.8	7.33
113	112.8	5.91	112.8	6.41	112.8	6.90	112.8	7.39
114	113.8	5.97	113.8	6.46	113.8	6.96	113.8	7.46
115	114.8	6.02	114.8	6.52	114.8	7.02	114.8	7.52
116	115.8	6.07	115.8	6.58	115.8	7.08	115.8	7.59
117	116.8	6.12	116.8	6.63	116.8	7.14	116.7	7.65
118	117.8	6.18	117.8	6.69	117.8	7.20	117.7	7.72
119	118.8	6.23	118.8	6.75	118.8	7.26	118.7	7.78
120	119.8	6.28	119.8	6.80	119.8	7.39	119.7	7.85
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
1	1.00	0.07	1.00	0.07	1.00	0.08	1.00	0.08
2	2.00	0.14	1.99	0.15	1.99	0.16	1.99	0.17
3	2.99	0.21	2.99	0.22	2.99	0.24	2.99	0.25
4	3.99	0.28	3.99	0.30	3.99	0.31	3.99	0.33
5	4.99	0.35	4.99	0.37	4.98	0.39	4.98	0.41
6	5.99	0.42	5.98	0.44	5.98	0.47	5.98	0.50
7	6.98	0.49	6.98	0.52	6.98	0.55	6.98	0.58
8	7.98	0.56	7.98	0.59	7.98	0.63	7.97	0.66
9	8.98	0.63	8.98	0.67	8.97	0.71	8.97	0.75
10	9.98	0.70	9.97	0.74	9.97	0.78	9.97	0.83
11	10.97	0.77	10.97	0.82	10.97	0.86	10.96	0.91
12	11.97	0.84	11.97	0.89	11.96	0.94	11.96	0.99
13	12.97	0.91	12.96	0.96	12.96	1.02	12.96	1.08
14	13.97	0.98	13.96	1.04	13.96	1.10	13.95	1.16
15	14.96	1.05	14.96	1.11	14.95	1.18	14.95	1.24
16	15.96	1.12	15.96	1.19	15.95	1.26	15.95	1.33
17	16.96	1.19	16.95	1.26	16.95	1.33	16.94	1.41
18	17.96	1.26	17.95	1.33	17.94	1.41	17.94	1.49
19	18.95	1.33	18.95	1.41	18.94	1.49	18.93	1.57
20	19.95	1.40	19.95	1.48	19.94	1.57	19.93	1.66
21	20.95	1.46	20.94	1.56	20.94	1.65	20.93	1.74
22	21.95	1.53	21.94	1.63	21.93	1.73	21.92	1.82
23	22.94	1.60	22.94	1.70	22.93	1.80	22.92	1.90
24	23.94	1.67	23.93	1.78	23.93	1.88	23.92	1.99
25	24.94	1.74	24.93	1.85	24.92	1.96	24.91	2.07
26	25.94	1.81	25.93	1.93	25.92	2.04	25.91	2.15
27	26.93	1.88	26.93	2.00	26.92	2.12	26.91	2.24
28	27.93	1.95	27.92	2.08	27.91	2.20	27.90	2.32
29	28.93	2.02	28.92	2.15	28.91	2.28	28.90	2.40
30	29.93	2.09	29.92	2.22	29.91	2.35	29.90	2.48
31	30.92	2.16	30.91	2.30	30.90	2.43	30.89	2.57
32	31.92	2.23	31.91	2.37	31.90	2.51	31.89	2.65
33	32.92	2.30	32.91	2.45	32.90	2.59	32.89	2.73
34	33.92	2.37	33.91	2.52	33.90	2.67	33.88	2.82
35	34.91	2.44	34.90	2.59	34.89	2.75	34.88	2.90
36	35.91	2.51	35.90	2.67	35.89	2.82	35.88	2.98
37	36.91	2.58	36.90	2.74	36.89	2.90	36.87	3.06
38	37.91	2.65	37.90	2.82	37.88	2.98	37.87	3.15
39	38.91	2.72	38.89	2.89	38.88	3.06	38.87	3.23
40	39.90	2.79	39.89	2.96	39.88	3.14	39.86	3.31
41	40.90	2.86	40.89	3.04	40.87	3.22	40.86	3.40
42	41.90	2.93	41.88	3.11	41.87	3.30	41.86	3.48
43	42.90	3.00	42.88	3.19	42.87	3.37	42.85	3.56
44	43.89	3.07	43.88	3.26	43.86	3.45	43.85	3.64
45	44.89	3.14	44.88	3.33	44.86	3.53	44.85	3.73
46	45.89	3.21	45.87	3.41	45.86	3.61	45.84	3.81
47	46.89	3.28	46.87	3.48	46.86	3.69	46.84	3.89
48	47.88	3.35	47.87	3.56	47.85	3.77	47.84	3.97
49	48.88	3.42	48.87	3.63	48.85	3.84	48.83	4.06
50	49.88	3.49	49.86	3.71	49.85	3.92	49.83	4.14
51	50.88	3.56	50.86	3.78	50.84	4.00	50.82	4.22
52	51.87	3.63	51.86	3.85	51.84	4.08	51.82	4.31
53	52.87	3.70	52.85	3.93	52.84	4.16	52.82	4.39
54	53.87	3.77	53.85	4.00	53.83	4.24	53.81	4.47
55	54.87	3.84	54.85	4.08	54.83	4.32	54.81	4.55
56	55.86	3.91	55.85	4.15	55.83	4.39	55.81	4.64
57	56.86	3.98	56.84	4.22	56.82	4.47	56.80	4.72
58	57.86	4.05	57.84	4.30	57.82	4.55	57.80	4.80
59	58.86	4.12	58.84	4.37	58.82	4.63	58.80	4.89
60	59.85	4.19	59.84	4.45	59.82	4.71	59.79	4.97
Dist.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0' Lat	0' Dep	15' Lat.	15' Dep.	30' Lat	30' Dep.	45' Lat.	45' Dep.
61	60.85	4.26	60.83	4.52	60.81	4.79	60.79	5.05
62	61.85	4.32	61.83	4.59	61.81	4.86	61.79	5.13
63	62.85	4.39	62.83	4.67	62.81	4.94	62.78	5.22
64	63.84	4.46	63.82	4.74	63.80	5.02	63.78	5.30
65	64.84	4.53	64.82	4.82	64.80	5.10	64.78	5.38
66	65.84	4.60	65.82	4.89	65.80	5.13	65.77	5.47
67	66.84	4.67	66.82	4.97	66.79	5.26	66.77	5.55
68	67.83	4.74	67.81	5.04	67.79	5.34	67.77	5.63
69	68.83	4.81	68.81	5.11	68.79	5.41	68.76	5.71
70	69.83	4.88	69.81	5.19	69.78	5.49	69.76	5.80
71	70.83	4.95	70.80	5.26	70.78	5.57	70.76	5.88
72	71.82	5.02	71.80	5.34	71.78	5.65	71.75	5.96
73	72.82	5.09	72.80	5.41	72.78	5.73	72.75	6.05
74	73.82	5.16	73.80	5.48	73.77	5.81	73.75	6.13
75	74.82	5.23	74.79	5.56	74.77	5.88	74.74	6.21
76	75.81	5.30	75.79	5.63	75.77	5.96	75.74	6.29
77	76.81	5.37	76.79	5.71	76.76	6.04	76.74	6.38
78	77.81	5.44	77.79	5.78	77.76	6.12	77.73	6.46
79	78.81	5.51	78.78	5.85	78.76	6.20	78.73	6.54
80	79.81	5.58	79.78	5.93	79.75	6.28	79.73	6.62
81	80.80	5.65	80.78	6.00	80.75	6.36	80.72	6.71
82	81.80	5.72	81.77	6.08	81.75	6.43	81.72	6.79
83	82.80	5.79	82.77	6.15	82.74	6.51	82.71	6.87
84	83.80	5.86	83.77	6.23	83.74	6.59	83.71	6.96
85	84.79	5.93	84.77	6.30	84.74	6.67	84.71	7.04
86	85.79	6.00	85.76	6.37	85.73	6.75	85.70	7.12
87	86.79	6.07	86.76	6.45	86.73	6.83	86.70	7.20
88	87.79	6.14	87.76	6.52	87.73	6.90	87.70	7.29
89	88.78	6.21	88.76	6.60	88.73	6.98	88.69	7.37
90	89.78	6.28	89.75	6.67	89.72	7.06	89.69	7.45
91	90.78	6.35	90.75	6.74	90.72	7.14	90.69	7.54
92	91.78	6.42	91.75	6.82	91.72	7.22	91.68	7.62
93	92.77	6.49	92.74	6.89	92.71	7.30	92.68	7.70
94	93.77	6.56	93.74	6.97	93.71	7.38	93.68	7.78
95	94.77	6.63	94.74	7.04	94.71	7.45	94.67	7.87
96	95.77	6.70	95.74	7.11	95.70	7.53	95.67	7.95
97	96.76	6.77	96.73	7.19	96.70	7.61	96.67	8.03
98	97.76	6.84	97.73	7.26	97.70	7.69	97.66	8.12
99	98.76	6.91	98.73	7.34	98.69	7.77	98.66	8.20
100	99.76	6.98	99.73	7.41	99.69	7.85	99.66	8.28
101	100.8	7.05	100.7	7.49	100.7	7.92	100.6	8.36
102	101.8	7.12	101.7	7.56	101.7	8.00	101.6	8.45
103	102.7	7.18	102.7	7.63	102.7	8.08	102.6	8.53
104	103.7	7.25	103.7	7.71	103.7	8.16	103.6	8.61
105	104.7	7.32	104.7	7.78	104.7	8.24	104.6	8.69
106	105.7	7.39	105.7	7.86	105.7	8.32	105.6	8.78
107	106.7	7.46	106.7	7.93	106.7	8.40	106.6	8.86
108	107.7	7.53	107.7	8.00	107.7	8.47	107.6	8.94
109	108.7	7.60	108.7	8.08	108.7	8.55	108.6	9.03
110	109.7	7.67	109.7	8.15	109.7	8.63	109.6	9.11
111	110.7	7.74	110.7	8.23	110.7	8.71	110.6	9.19
112	111.7	7.81	111.7	8.30	111.7	8.79	111.6	9.27
113	112.7	7.88	112.7	8.37	112.7	8.87	112.6	9.36
114	113.7	7.95	113.7	8.45	113.6	8.94	113.6	9.44
115	114.7	8.02	114.7	8.52	114.6	9.02	114.6	9.52
116	115.7	8.09	115.7	8.60	115.6	9.10	115.6	9.61
117	116.7	8.16	116.7	8.67	116.6	9.18	116.6	9.69
118	117.7	8.23	117.7	8.74	117.6	9.26	117.6	9.77
119	118.7	8.30	118.7	8.82	118.6	9.34	118.6	9.85
120	119.7	8.37	119.7	8.89	119.6	9.42	119.6	9.94
Dist.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0'		45'		30'		15'	

85 DEGREES.

Dist.	0′		15′		30′		45′	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
1	1.00	0.09	1.00	0.09	1.00	0.10	1.00	0.10
2	1.99	0.17	1.99	0.18	1.99	0.19	1.99	0.20
3	2.99	0.26	2.99	0.27	2.99	0.29	2.98	0.30
4	3.98	0.35	3.98	0.37	3.98	0.38	3.98	0.40
5	4.98	0.44	4.98	0.46	4.98	0.48	4.97	0.50
6	5.98	0.52	5.97	0.55	5.97	0.58	5.97	0.60
7	6.97	0.61	6.97	0.64	6.97	0.67	6.96	0.70
8	7.97	0.70	7.97	0.73	7.96	0.77	7.96	0.80
9	8.97	0.78	8.96	0.82	8.96	0.86	8.95	0.90
10	9.96	0.87	9.96	0.92	9.95	0.96	9.95	1.00
11	10.96	0.96	10.95	1.01	10.95	1.05	10.94	1.10
12	11.95	1.05	11.95	1.10	11.94	1.15	11.94	1.20
13	12.95	1.13	12.95	1.19	12.94	1.25	12.93	1.30
14	13.95	1.22	13.94	1.28	13.94	1.34	13.93	1.40
15	14.94	1.31	14.94	1.37	14.93	1.44	14.92	1.50
16	15.94	1.39	15.93	1.46	15.93	1.53	15.92	1.60
17	16.94	1.48	16.93	1.56	16.92	1.63	16.91	1.70
18	17.93	1.57	17.92	1.65	17.92	1.73	17.91	1.80
19	18.93	1.66	18.92	1.74	18.91	1.82	18.90	1.90
20	19.93	1.74	19.92	1.83	19.91	1.92	19.90	2.00
21	20.92	1.83	20.91	1.92	20.90	2.01	20.89	2.10
22	21.92	1.92	21.91	2.01	21.90	2.11	21.89	2.20
23	22.91	2.00	22.90	2.10	22.89	2.20	22.88	2.30
24	23.91	2.09	23.90	2.20	23.89	2.30	23.88	2.40
25	24.90	2.18	24.90	2.29	24.88	2.40	24.87	2.50
26	25.90	2.27	25.89	2.38	25.88	2.49	25.87	2.60
27	26.90	2.35	26.89	2.47	26.88	2.59	26.86	2.71
28	27.89	2.44	27.88	2.56	27.87	2.68	27.86	2.81
29	28.89	2.53	28.88	2.65	28.87	2.78	28.85	2.91
30	29.89	2.61	29.87	2.75	29.86	2.88	29.85	3.01
31	30.88	2.70	30.87	2.84	30.86	2.97	30.84	3.11
32	31.88	2.79	31.87	2.93	31.85	3.07	31.84	3.21
33	32.87	2.88	32.86	3.02	32.85	3.16	32.83	3.31
34	33.87	2.96	33.86	3.11	33.84	3.26	33.83	3.41
35	34.87	3.05	34.85	3.20	34.84	3.35	34.82	3.51
36	35.86	3.14	35.85	3.29	35.83	3.45	35.82	3.61
37	36.86	3.22	36.84	3.39	36.83	3.55	36.81	3.71
38	37.86	3.31	37.84	3.48	37.83	3.64	37.81	3.81
39	38.85	3.40	38.84	3.57	38.82	3.74	38.80	3.91
40	39.85	3.49	39.83	3.66	39.82	3.83	39.80	4.01
41	40.84	3.57	40.83	3.75	40.81	3.93	40.79	4.11
42	41.84	3.66	41.82	3.84	41.81	4.03	41.79	4.21
43	42.84	3.75	42.82	3.93	42.80	4.12	42.78	4.31
44	43.83	3.83	43.82	4.03	43.80	4.22	43.78	4.41
45	44.83	3.92	44.81	4.12	44.79	4.31	44.77	4.51
46	45.83	4.01	45.81	4.21	45.79	4.41	45.77	4.61
47	46.82	4.10	46.80	4.30	46.78	4.50	46.76	4.71
48	47.82	4.18	47.80	4.39	47.78	4.60	47.76	4.81
49	48.81	4.27	48.79	4.48	48.77	4.70	48.75	4.91
50	49.81	4.36	49.79	4.58	49.77	4.79	49.75	5.01
51	50.81	4.44	50.79	4.67	50.77	4.89	50.74	5.11
52	51.80	4.53	51.78	4.76	51.76	4.98	51.74	5.21
53	52.80	4.62	52.78	4.85	52.76	5.08	52.73	5.31
54	53.79	4.71	53.77	4.94	53.75	5.18	53.73	5.41
55	54.79	4.79	54.77	5.03	54.75	5.27	54.72	5.51
56	55.79	4.88	55.77	5.12	55.74	5.37	55.72	5.61
57	56.78	4.97	56.76	5.22	56.74	5.46	56.71	5.71
58	57.78	5.06	57.76	5.31	57.73	5.56	57.71	5.81
59	58.78	5.14	58.75	5.40	58.73	5.65	58.70	5.91
60	59.77	5.23	59.75	5.49	59.72	5.75	59.70	6.01
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
Dist.	0′		45′		30′		15′	

Dist.	0' Lat.	0' Dep.	15' Lat.	15' Dep.	30' Lat.	30' Dep.	45' Lat.	45' Dep.
61	60.77	5.32	60.74	5.58	60.72	5.85	60.69	6.11
62	61.76	5.40	61.74	5.67	61.71	5.94	61.69	6.21
63	62.76	5.49	62.74	5.76	62.71	6.04	62.68	6.31
64	63.76	5.58	63.73	5.86	63.71	6.13	63.68	6.41
65	64.75	5.67	64.73	5.95	64.70	6.23	64.67	6.51
66	65.75	5.75	65.72	6.04	65.70	6.33	65.67	6.61
67	66.75	5.84	66.72	6.13	66.69	6.42	66.66	6.71
68	67.74	5.93	67.71	6.22	67.69	6.52	67.66	6.81
69	68.74	6.01	68.71	6.31	68.68	6.61	68.65	6.91
70	69.73	6.10	69.71	6.41	69.68	6.71	69.65	7.01
71	70.73	6.19	70.70	6.50	70.67	6.81	70.64	7.11
72	71.73	6.28	71.70	6.59	71.67	6.90	71.64	7.21
73	72.72	6.36	72.69	6.68	72.66	7.00	72.63	7.31
74	73.72	6.45	73.69	6.77	73.66	7.09	73.63	7.41
75	74.71	6.54	74.69	6.86	74.65	7.19	74.62	7.51
76	75.71	6.62	75.68	6.95	75.65	7.28	75.62	7.61
77	76.71	6.71	76.68	7.05	76.65	7.38	76.61	7.71
78	77.70	6.80	77.67	7.14	77.64	7.48	77.61	7.81
79	78.70	6.89	78.67	7.23	78.64	7.57	78.60	7.91
80	79.70	6.97	79.66	7.32	79.63	7.67	79.60	8.02
81	80.69	7.06	80.66	7.41	80.63	7.76	80.59	8.12
82	81.69	7.15	81.66	7.50	81.62	7.86	81.59	8.22
83	82.68	7.23	82.65	7.59	82.62	7.96	82.58	8.32
84	83.68	7.32	83.65	7.69	83.61	8.05	83.58	8.42
85	84.68	7.41	84.64	7.78	84.61	8.15	84.57	8.52
86	85.67	7.50	85.64	7.87	85.60	8.24	85.57	8.62
87	86.67	7.58	86.64	7.96	86.60	8.34	86.56	8.72
88	87.67	7.67	87.63	8.05	87.59	8.43	87.56	8.82
89	88.66	7.76	88.63	8.14	88.59	8.53	88.55	8.92
90	89.66	7.84	89.62	8.24	89.59	8.63	89.55	9.02
91	90.65	7.93	90.62	8.33	90.58	8.72	90.54	9.12
92	91.65	8.02	91.61	8.42	91.58	8.82	91.54	9.22
93	92.65	8.11	92.61	8.51	92.57	8.91	92.53	9.32
94	93.64	8.19	93.61	8.60	93.57	9.01	93.53	9.42
95	94.64	8.28	94.60	8.69	94.56	9.11	94.52	9.52
96	95.63	8.37	95.60	8.78	95.56	9.20	95.52	9.62
97	96.63	8.45	96.59	8.88	96.55	9.30	96.51	9.72
98	97.63	8.54	97.59	8.97	97.55	9.39	97.51	9.82
99	98.62	8.63	98.58	9.06	98.54	9.49	98.50	9.92
100	99.62	8.72	99.58	9.15	99.54	9.58	99.50	10.02
101	100.6	8.80	100.6	9.24	100.5	9.68	100.5	10.12
102	101.6	8.89	101.6	9.33	101.5	9.78	101.5	10.22
103	102.6	8.98	102.6	9.42	102.5	9.87	102.5	10.32
104	103.6	9.06	103.6	9.52	103.5	9.97	103.5	10.42
105	104.6	9.15	104.6	9.61	104.5	10.06	104.5	10.52
106	105.6	9.24	105.6	9.70	105.5	10.16	105.5	10.62
107	106.6	9.33	106.6	9.79	106.5	10.26	106.5	10.72
108	107.6	9.41	107.5	9.88	107.5	10.35	107.5	10.82
109	108.6	9.50	108.5	9.97	108.5	10.45	108.5	10.92
110	109.6	9.59	109.5	10.07	109.5	10.54	109.4	11.02
111	110.6	9.67	110.5	10.16	110.5	10.64	110.4	11.12
112	111.6	9.76	111.5	10.25	111.5	10.73	111.4	11.22
113	112.6	9.85	112.5	10.34	112.5	10.83	112.4	11.32
114	113.6	9.94	113.5	10.43	113.5	10.93	113.4	11.42
115	114.6	10.02	114.5	10.52	114.5	11.02	114.4	11.52
116	115.6	10.11	115.5	10.61	115.5	11.12	115.4	11.62
117	116.6	10.20	116.5	10.71	116.5	11.21	116.4	11.72
118	117.6	10.28	117.5	10.80	117.5	11.31	117.4	11.82
119	118.5	10.37	118.5	10.89	118.5	11.40	118.4	11.92
120	119.5	10.46	119.5	10.98	119.5	11.50	119.4	12.02
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0'		45'		30'		15'	

Dist.	0' Lat.	0' Dep.	15' Lat.	15' Dep.	30' Lat.	30' Dep.	45' Lat.	45' Dep.
1	0.99	0.10	0.99	0.11	0.99	0.11	0.99	0.12
2	1.99	0.21	1.99	0.22	1.99	0.23	1.99	0.24
3	2.98	0.31	2.98	0.33	2.98	0.34	2.98	0.35
4	3.98	0.42	3.98	0.44	3.97	0.45	3.97	0.47
5	4.97	0.52	4.97	0.54	4.97	0.57	4.97	0.59
6	5.97	0.63	5.96	0.65	5.96	0.68	5.96	0.71
7	6.96	0.73	6.96	0.76	6.96	0.79	6.95	0.82
8	7.96	0.84	7.95	0.87	7.95	0.91	7.94	0.94
9	8.95	0.94	8.95	0.98	8.94	1.02	8.94	1.06
10	9.95	1.05	9.94	1.09	9.94	1.13	9.93	1.18
11	10.94	1.15	10.93	1.20	10.93	1.25	10.92	1.29
12	11.93	1.25	11.93	1.31	11.92	1.36	11.92	1.41
13	12.93	1.36	12.92	1.42	12.92	1.47	12.91	1.53
14	13.92	1.46	13.92	1.52	13.91	1.58	13.90	1.65
15	14.92	1.57	14.91	1.63	14.90	1.70	14.90	1.76
16	15.91	1.67	15.90	1.74	15.90	1.81	15.89	1.88
17	16.91	1.78	16.90	1.85	16.89	1.92	16.88	2.00
18	17.90	1.88	17.89	1.96	17.88	2.04	17.88	2.12
19	18.90	1.99	18.89	2.07	18.88	2.15	18.87	2.23
20	19.89	2.09	19.88	2.18	19.87	2.26	19.86	2.35
21	20.89	2.20	20.88	2.29	20.86	2.38	20.85	2.47
22	21.88	2.30	21.87	2.40	21.86	2.49	21.85	2.59
23	22.87	2.40	22.86	2.50	22.85	2.60	22.84	2.70
24	23.87	2.51	23.86	2.61	23.85	2.72	23.83	2.82
25	24.86	2.61	24.85	2.72	24.84	2.83	24.83	2.94
26	25.86	2.72	25.85	2.83	25.83	2.94	25.82	3.06
27	26.85	2.82	26.84	2.94	26.83	3.06	26.81	3.17
28	27.85	2.93	27.83	3.05	27.82	3.17	27.81	3.29
29	28.84	3.03	28.83	3.16	28.81	3.28	28.80	3.41
30	29.84	3.14	29.82	3.27	29.81	3.40	29.79	3.53
31	30.83	3.24	30.82	3.37	30.80	3.51	30.79	3.64
32	31.82	3.34	31.81	3.48	31.79	3.62	31.78	3.76
33	32.82	3.45	32.80	3.59	32.79	3.74	32.77	3.88
34	33.81	3.55	33.80	3.70	33.78	3.85	33.76	4.00
35	34.81	3.66	34.79	3.81	34.78	3.96	34.76	4.11
36	35.80	3.76	35.79	3.92	35.77	4.08	35.75	4.23
37	36.80	3.87	36.78	4.03	36.76	4.19	36.74	4.35
38	37.79	3.97	37.77	4.14	37.76	4.30	37.74	4.47
39	38.79	4.08	38.77	4.25	38.75	4.41	38.73	4.58
40	39.78	4.18	39.76	4.35	39.74	4.53	39.72	4.70
41	40.78	4.29	40.76	4.46	40.74	4.64	40.72	4.82
42	41.77	4.39	41.75	4.57	41.73	4.75	41.71	4.94
43	42.76	4.49	42.74	4.68	42.72	4.87	42.70	5.05
44	43.76	4.60	43.74	4.79	43.72	4.98	43.70	5.17
45	44.75	4.70	44.73	4.90	44.71	5.09	44.69	5.29
46	45.75	4.81	45.73	5.01	45.70	5.21	45.68	5.41
47	46.74	4.91	46.72	5.12	46.70	5.32	46.67	5.52
48	47.74	5.02	47.71	5.23	47.69	5.43	47.67	5.64
49	48.73	5.12	48.71	5.33	48.69	5.55	48.66	5.76
50	49.73	5.23	49.70	5.44	49.68	5.66	49.65	5.88
51	50.73	5.33	50.70	5.55	50.67	5.77	50.65	5.99
52	51.72	5.44	51.69	5.66	51.67	5.89	51.64	6.11
53	52.71	5.54	52.69	5.77	52.66	6.00	52.63	6.23
54	53.70	5.64	53.68	5.88	53.65	6.11	53.63	6.35
55	54.70	5.75	54.67	5.99	54.65	6.23	54.62	6.46
56	55.69	5.85	55.67	6.10	55.64	6.34	55.61	6.58
57	56.69	5.96	56.66	6.21	56.63	6.45	56.60	6.70
58	57.68	6.06	57.66	6.31	57.63	6.57	57.60	6.82
59	58.68	6.17	58.65	6.42	58.62	6.68	58.59	6.93
60	59.67	6.27	59.64	6.53	59.61	6.79	59.58	7.05
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0'		45'		30'		15'	

Dist.	0' Lat.	0' Dep.	15' Lat.	15' Dep.	30' Lat.	30' Dep.	45' Lat.	45' Dep.
61	60.67	6.38	60.64	6.64	60.61	6.91	60.58	7.17
62	61.66	6.48	61.63	6.75	61.60	7.02	61.57	7.29
63	62.65	6.59	62.63	6.86	62.60	7.13	62.56	7.40
64	63.65	6.69	63.62	6.97	63.59	7.25	63.56	7.52
65	64.64	6.79	64.61	7.08	64.58	7.36	64.55	7.64
66	65.64	6.90	65.61	7.19	65.58	7.47	65.54	7.76
67	66.63	7.00	66.60	7.29	66.57	7.58	66.54	7.88
68	67.63	7.11	67.60	7.40	67.56	7.70	67.53	7.99
69	68.62	7.21	68.59	7.51	68.56	7.81	68.52	8.11
70	69.62	7.32	69.58	7.62	69.55	7.92	69.51	8.22
71	70.61	7.42	70.58	7.73	70.54	8.04	70.51	8.35
72	71.61	7.53	71.57	7.84	71.54	8.15	71.50	8.46
73	72.60	7.63	72.57	7.95	72.53	8.26	72.49	8.58
74	73.59	7.74	73.56	8.06	73.52	8.38	73.49	8.70
75	74.59	7.84	74.55	8.17	74.52	8.49	74.48	8.82
76	75.58	7.94	75.55	8.27	75.51	8.60	75.47	8.93
77	76.58	8.05	76.54	8.38	76.51	8.72	76.47	9.05
78	77.57	8.15	77.54	8.49	77.50	8.83	77.46	9.17
79	78.57	8.26	78.53	8.60	78.49	8.94	78.45	9.29
80	79.56	8.36	79.52	8.71	79.49	9.06	79.45	9.40
81	80.56	8.47	80.52	8.82	80.48	9.17	80.44	9.52
82	81.55	8.57	81.51	8.93	81.47	9.28	81.43	9.64
83	82.55	8.68	82.51	9.04	82.47	9.40	82.42	9.76
84	83.54	8.78	83.50	9.14	83.46	9.51	83.42	9.87
85	84.53	8.88	84.49	9.25	84.45	9.62	84.41	9.99
86	85.53	8.99	85.49	9.36	85.45	9.74	85.40	10.11
87	86.52	9.09	86.48	9.47	86.44	9.85	86.40	10.23
88	87.52	9.20	87.48	9.58	87.43	9.96	87.39	10.34
89	88.51	9.30	88.47	9.69	88.43	10.08	88.38	10.46
90	89.51	9.41	89.47	9.80	89.42	10.19	89.38	10.58
91	90.50	9.51	90.46	9.91	90.42	10.30	90.37	10.70
92	91.50	9.62	91.45	10.02	91.41	10.41	91.36	10.81
93	92.49	9.72	92.45	10.12	92.40	10.53	92.36	10.93
94	93.49	9.83	93.44	10.23	93.40	10.64	93.35	11.05
95	94.48	9.93	94.44	10.34	94.39	10.75	94.34	11.17
96	95.47	10.03	95.43	10.45	95.38	10.87	95.33	11.28
97	96.47	10.14	96.42	10.56	96.38	10.98	96.33	11.40
98	97.46	10.24	97.42	10.67	97.37	11.09	97.32	11.52
99	98.46	10.35	98.41	10.78	98.36	11.21	98.31	11.64
100	99.45	10.45	99.41	10.89	99.36	11.32	99.31	11.75
101	100.4	10.56	100.4	11.00	100.3	11.43	100.3	11.87
102	101.4	10.66	101.4	11.10	101.3	11.55	101.3	11.99
103	102.4	10.77	102.4	11.21	102.3	11.66	102.3	12.11
104	103.4	10.87	103.4	11.32	103.3	11.77	103.3	12.22
105	104.4	10.98	104.4	11.43	104.3	11.89	104.3	12.34
106	105.4	11.08	105.4	11.54	105.3	12.00	105.3	12.46
107	106.4	11.18	106.4	11.65	106.3	12.11	106.3	12.58
108	107.4	11.29	107.4	11.76	107.3	12.23	107.3	12.69
109	108.4	11.39	108.4	11.87	108.3	12.34	108.2	12.81
110	109.4	11.50	109.3	11.98	109.3	12.45	109.2	12.93
111	110.4	11.60	110.3	12.08	110.3	12.57	110.2	13.05
112	111.4	11.71	111.3	12.19	111.3	12.68	111.2	13.16
113	112.4	11.81	112.3	12.30	112.3	12.79	112.2	13.28
114	113.4	11.92	113.3	12.41	113.3	12.91	113.2	13.40
115	114.4	12.02	114.3	12.52	114.3	13.02	114.2	13.52
116	115.4	12.13	115.3	12.63	115.3	13.13	115.2	13.63
117	116.4	12.23	116.3	12.74	116.3	13.24	116.2	13.75
118	117.4	12.33	117.3	12.85	117.2	13.36	117.2	13.87
119	118.3	12.44	118.3	12.96	118.2	13.47	118.2	13.99
120	119.3	12.54	119.3	13.06	119.2	13.58	119.2	14.10
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0'		45'		30'		15'	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
1	0.99	0.12	0.99	0.13	0.99	0.13	0.99	0.13
2	1.99	0.24	1.98	0.25	1.98	0.26	1.98	0.27
3	2.98	0.37	2.98	9.38	2.97	0.39	2.97	0.40
4	3.97	0.49	3.97	0.50	3.97	0.52	3.96	0.54
5	4.96	0.61	4.96	0.63	4.96	0.65	4.95	0.67
6	5.96	0.73	5.95	0.76	5.95	0.78	5.95	0.81
7	6.95	0.85	6.94	0.88	6.94	0.91	6.94	0.94
8	7.94	0.98	7.94	1.01	7.93	1.04	7.93	1.08
9	8.93	1.10	8.93	1.14	8.92	1.17	8.92	1.21
10	9.93	1.22	9.92	1.26	9.91	1.31	9.91	1.35
11	10.92	1.34	10.91	1.39	10.91	1.44	10.90	1.48
12	11.91	1.46	11.90	1.51	11.90	1.57	11.89	1.62
13	12.90	1.58	12.90	1.64	12.89	1.70	12.88	1.75
14	13.90	1.71	13.89	1.77	13.88	1.83	13.87	1.89
15	14.89	1.83	14.88	1.89	14.87	1.96	14.86	2.02
16	15.88	1.95	15.87	2.02	15.86	2.09	15.85	2.16
17	16.87	2.07	16.86	2.15	16.85	2.22	16.84	2.29
18	17.87	2.19	17.86	2.27	17.85	2.35	17.84	2.43
19	18.86	2.32	18.85	2.40	18.84	2.48	18.83	2.56
20	19.85	2.44	19.84	2.52	19.83	2.61	19.82	2.70
21	20.84	2.56	20.83	2.65	20.82	2.74	20.81	2.83
22	21.84	2.68	21.82	2.78	21.81	2.87	21.80	2.97
23	22.83	2.80	22.82	2.90	22.80	3.00	22.79	3.10
24	23.82	2.92	23.81	3.03	23.79	3.13	23.78	3.24
25	24.81	3.05	24.80	3.16	24.79	3.26	24.77	3.37
26	25.81	3.17	25.79	3.28	25.78	3.39	25.76	3.51
27	26.80	3.29	26.78	3.41	26.77	3.52	26.75	3.64
28	27.79	3.41	27.78	3.53	27.76	3.65	27.74	3.78
29	28.78	3.53	28.77	3.66	28.75	3.79	28.74	3.91
30	29.78	3.66	29.76	3.79	29.74	3.92	29.73	4.05
31	30.77	3.78	30.75	3.91	30.73	4.05	30.72	4.18
32	31.76	3.90	31.74	4.04	31.73	4.18	31.71	4.32
33	32.75	4.02	32.74	4.16	32.72	4.31	32.70	4.45
34	33.75	4.14	33.73	4.29	33.71	4.44	33.69	4.58
35	34.74	4.27	34.72	4.42	34.70	4.57	34.68	4.72
36	35.73	4.39	35.71	4.54	35.69	4.70	35.67	4.85
37	36.72	4.51	36.70	4.67	36.68	4.83	36.66	4.99
38	37.72	4.63	37.70	4.80	37.67	4.96	37.65	5.12
39	38.71	4.75	38.69	4.92	38.67	5.09	38.64	5.26
40	39.70	4.87	39.68	5.05	39.66	5.22	39.63	5.39
41	40.69	5.00	40.67	5.17	40.65	5.35	40.63	5.53
42	41.69	5.12	41.66	5.30	41.64	5.48	41.62	5.66
43	42.68	5.24	42.66	5.43	42.63	5.61	42.61	5.80
44	43.67	5.36	43.65	5.55	43.62	5.74	43.60	5.93
45	44.66	5.48	44.64	5.68	44.62	5.87	44.59	6.07
46	45.66	5.61	45.63	5.81	45.61	6.00	45.58	6.20
47	46.65	5.73	46.62	5.93	46.60	6.13	46.97	6.34
48	47.64	5.85	47.62	6.06	47.59	6.27	47.56	6.47
49	48.63	5.97	48.61	6.18	48.58	6.40	48.55	6.61
50	49.63	6.09	49.60	6.31	49.57	6.53	49.54	6.74
51	50.62	6.22	50.59	6.44	50.56	6.66	50.53	6.88
52	51.61	6.34	51.58	6.56	51.56	6.79	51.53	7.01
53	52.60	6.46	52.58	6.69	52.55	6.92	52.52	7.15
54	53.60	6.58	53.57	6.81	53.54	7.05	53.51	7.28
55	54.59	6.70	54.56	6.94	54.53	7.18	54.50	7.42
56	55.58	6.82	55.55	7.07	55.52	7.31	55.49	7.55
57	56.58	6.95	56.54	7.19	56.51	7.44	56.48	7.69
58	57.57	7.07	57.54	7.32	57.50	7.57	57.47	7.82
59	58.56	7.19	58.53	7.45	58.50	7.70	58.46	7.96
60	59.55	7.31	59.52	7.57	59.49	7.83	59.45	8.09
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
61	60.55	7.43	60.51	7.70	60.48	7.96	60.44	8.23
62	61.54	7.56	61.50	7.82	61.47	8.09	61.43	8.36
63	62.53	7.68	62.50	7.95	62.46	8.22	62.42	8.50
64	63.52	7.80	63.49	8.08	63.45	8.35	63.42	8.63
65	64.52	7.92	64.48	8.20	64.44	8.48	64.41	8.77
66	65.51	8.04	65.47	8.33	65.44	8.61	65.40	8.90
67	66.50	8.17	66.46	8.46	66.43	8.75	66.39	9.04
68	67.49	8.29	67.46	8.58	67.42	8.88	67.38	9.17
69	68.49	8.41	68.45	8.71	68.41	9.01	68.37	9.30
70	69.48	8.53	69.44	8.83	69.40	9.14	69.36	9.44
71	70.47	8.65	70.43	8.96	70.39	9.27	70.35	9.57
72	71.46	8.77	71.42	9.09	71.38	9.40	71.34	9.71
73	72.46	8.90	72.42	9.21	72.38	9.53	72.33	9.84
74	73.45	9.02	73.41	9.34	73.37	9.66	73.32	9.98
75	74.44	9.14	74.40	9.46	74.36	9.79	74.31	10.11
76	75.43	9.26	75.39	9.59	75.35	9.92	75.31	10.25
77	76.43	9.38	76.38	9.72	76.34	10.05	76.30	10.38
78	77.42	9.51	77.38	9.84	77.33	10.18	77.29	10.52
79	78.41	9.63	78.37	9.97	78.32	10.31	78.28	10.65
80	79.40	9.75	79.36	10.10	79.32	10.44	79.27	10.79
81	80.40	9.87	80.35	10.22	80.31	10.57	80.26	10.92
82	81.39	9.99	81.34	10.35	81.30	10.70	81.25	11.06
83	82.38	10.12	82.34	10.47	82.29	10.83	82.24	11.19
84	83.37	10.24	83.33	10.60	83.28	10.96	83.23	11.33
85	84.37	10.36	84.32	10.73	84.27	11.09	84.22	11.46
86	85.36	10.48	85.31	10.85	85.26	11.23	85.21	11.60
87	86.35	10.60	86.30	10.98	86.26	11.36	86.21	11.73
88	87.34	10.72	87.30	11.11	87.25	11.49	87.20	11.87
89	88.34	10.85	88.29	11.23	88.24	11.62	88.19	12.00
90	89.33	10.97	89.28	11.36	89.23	11.75	89.18	12.14
91	90.32	11.09	90.27	11.48	90.22	11.88	90.17	12.27
92	91.31	11.21	91.26	11.61	91.21	12.01	91.16	12.41
93	92.31	11.33	92.26	11.74	92.20	12.14	92.15	12.54
94	93.30	11.46	93.25	11.86	93.20	12.27	93.14	12.68
95	94.29	11.58	94.24	11.99	94.19	12.40	94.13	12.81
96	95.28	11.70	95.23	12.12	95.18	12.53	95.12	12.95
97	96.28	11.82	96.22	12.24	96.17	12.66	96.11	13.08
98	97.27	11.94	97.22	12.37	97.16	12.79	97.10	13.22
99	98.26	12.07	98.21	12.49	98.15	12.92	98.10	13.35
100	99.25	12.19	99.20	12.62	99.14	13.05	99.09	13.49
101	100.2	12.31	100.2	12.75	100.1	13.18	100.1	13.62
102	101.2	12.43	101.2	12.87	101.1	13.31	101.1	13.75
103	102.2	12.55	102.2	13.00	102.1	13.44	102.1	13.89
104	103.2	12.67	103.2	13.12	103.1	13.57	103.1	14.02
105	104.2	12.80	104.2	13.25	104.1	13.71	104.0	14.16
106	105.2	12.92	105.2	13.38	105.1	13.84	105.0	14.29
107	106.2	13.04	106.1	13.50	106.1	13.97	106.0	14.43
108	107.2	13.16	107.1	13.63	107.1	14.10	107.0	14.56
109	108.2	13.28	108.1	13.76	108.1	14.23	108.0	14.70
110	109.2	13.41	109.1	13.88	109.1	14.36	109.0	14.83
111	110.2	13.53	110.1	14.01	110.1	14.49	110.0	14.97
112	111.2	13.65	111.1	14.13	111.0	14.62	111.0	15.10
113	112.2	13.77	112.1	14.26	112.0	14.75	112.0	15.24
114	113.2	13.89	113.1	14.39	113.0	14.88	113.0	15.37
115	114.1	14.02	114.1	14.51	114.0	15.01	113.9	15.51
116	115.1	14.14	115.1	14.64	115.0	15.14	114.9	15.64
117	116.1	14.26	116.1	14.77	116.0	15.27	115.9	15.78
118	117.1	14.38	117.1	14.89	117.0	15.40	116.9	15.91
119	118.1	14.50	118.0	15.02	118.0	15.53	117.9	16.05
120	119.1	14.62	119.0	15.14	119.0	15.66	118.9	16.18
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0' Lat.	0' Dep.	15' Lat.	15' Dep.	30' Lat.	30' Dep.	45' Lat.	45' Dep.
1	0.99	0.14	0.99	0.14	0.99	0.15	0.99	0.15
2	1.98	0.28	1.98	0.29	1.98	0.30	1.98	0.30
3	2.97	0.42	2.97	0.43	2.97	0.44	2.97	0.46
4	3.96	0.56	3.96	0.57	3.96	0.59	3.95	0.61
5	4.95	0.70	4.95	0.72	4.95	0.74	4.94	0.76
6	5.94	0.84	5.94	0.86	5.93	0.89	5.93	0.91
7	6.93	0.97	6.93	1.00	6.92	1.03	6.92	1.06
8	7.92	1.11	7.92	1.15	7.91	1.18	7.91	1.22
9	8.91	1.25	8.91	1.29	8.90	1.33	8.90	1.37
10	9.90	1.39	9.90	1.43	9.89	1.48	9.88	1.52
11	10.89	1.53	10.89	1.58	10.88	1.63	10.87	1.67
12	11.88	1.67	11.88	1.72	11.87	1.77	11.86	1.83
13	12.87	1.81	12.87	1.87	12.86	1.92	12.85	1.98
14	13.86	1.95	13.86	2.01	13.85	2.07	13.84	2.13
15	14.85	2.09	14.84	2.15	14.84	2.22	14.83	2.28
16	15.84	2.23	15.83	2.30	15.82	2.37	15.81	2.43
17	16.83	2.37	16.82	2.44	16.81	2.51	16.80	2.59
18	17.82	2.51	17.81	2.58	17.80	2.66	17.79	2.74
19	18.82	2.64	18.80	2.73	18.79	2.81	18.78	2.89
20	19.81	2.78	19.79	2.87	19.78	2.96	19.77	3.04
21	20.80	2.92	20.78	3.01	20.77	3.10	20.76	3.19
22	21.79	3.06	21.77	3.16	21.76	3.25	21.74	3.35
23	22.78	3.20	22.76	3.30	22.75	3.40	22.73	3.50
24	23.77	3.34	23.75	3.44	23.74	3.55	23.72	3.65
25	24.76	3.48	24.74	3.59	24.73	3.70	24.71	3.80
26	25.75	3.62	25.73	3.73	25.71	3.84	25.70	3.96
27	26.74	3.76	26.72	3.87	26.70	3.99	26.69	4.11
28	27.73	3.90	27.71	4.02	27.69	4.14	27.67	4.26
29	28.72	4.04	28.70	4.16	28.68	4.29	28.66	4.41
30	29.71	4.18	29.69	4.30	29.67	4.43	29.65	4.56
31	30.70	4.31	30.68	4.45	30.66	4.58	30.64	4.72
32	31.69	4.45	31.67	4.59	31.65	4.73	31.63	4.87
33	32.68	4.59	32.66	4.74	32.64	4.88	32.62	5.02
34	33.67	4.73	33.65	4.88	33.63	5.03	33.60	5.17
35	34.66	4.87	34.64	5.02	34.62	5.17	34.59	5.32
36	35.65	5.01	35.63	5.17	35.60	5.32	35.58	5.48
37	36.64	5.15	36.62	5.31	36.59	5.47	36.57	5.63
38	37.63	5.29	37.61	5.45	37.58	5.62	37.56	5.78
39	38.62	5.43	38.60	5.60	38.57	5.76	38.55	5.93
40	39.61	5.57	39.59	5.74	39.56	5.91	39.53	6.08
41	40.60	5.71	40.58	5.88	40.55	6.06	40.52	6.24
42	41.59	5.85	41.57	6.03	41.54	6.21	41.51	6.39
43	42.58	5.98	42.56	6.17	42.53	6.36	42.50	6.54
44	43.57	6.12	43.54	6.31	43.52	6.50	43.49	6.69
45	44.56	6.26	44.53	6.46	44.51	6.65	44.48	6.85
46	45.55	6.40	45.52	6.60	45.49	6.80	45.46	7.00
47	46.54	6.54	46.51	6.74	46.48	6.95	46.45	7.15
48	47.53	6.68	47.50	6.89	47.47	7.09	47.44	7.30
49	48.52	6.82	48.49	7.03	48.46	7.24	48.43	7.45
50	49.51	6.96	49.48	7.17	49.45	7.39	49.42	7.61
51	50.50	7.10	50.47	7.32	50.44	7.54	50.41	7.76
52	51.49	7.24	51.46	7.46	51.43	7.69	51.39	7.91
53	52.48	7.38	52.45	7.61	52.42	7.83	52.38	8.06
54	53.47	7.52	53.44	7.75	53.41	7.98	53.37	8.21
55	54.46	7.65	54.43	7.89	54.40	8.13	54.36	8.37
56	55.46	7.79	55.42	8.04	55.38	8.28	55.35	8.52
57	56.45	7.93	56.41	8.18	56.37	8.43	56.34	8.67
58	57.44	8.07	57.40	8.32	57.36	8.57	57.33	8.82
59	58.43	8.21	58.39	8.47	58.35	8.72	58.31	8.98
60	59.42	8.35	59.38	8.61	59.34	8.87	59.30	9.13
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0'		45'		30'		15'	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
61	60.41	8.49	60.37	8.75	60.33	9.02	60.29	9.28
62	61.40	8.63	61.36	8.90	61.32	9.16	61.28	9.43
63	62.39	8.77	62.35	9.04	62.31	9.31	62.27	9.58
64	63.38	8.91	63.34	9.18	63.30	9.46	63.26	9.74
65	64.37	9.05	64.33	9.33	64.29	9.61	64.24	9.89
66	65.36	9.19	65.32	9.47	65.28	9.76	65.23	10.04
67	66.35	9.32	66.31	9.61	66.26	9.90	66.22	10.19
68	67.34	9.46	67.30	9.76	67.25	10.05	67.21	10.34
69	68.33	9.60	68.29	9.90	68.24	10.20	68.20	10.50
70	69.32	9.74	69.28	10.04	69.23	10.35	69.19	10.65
71	70.31	9.88	70.27	10.19	70.22	10.49	70.17	10.80
72	71.30	10.02	71.25	10.33	71.21	10.64	71.16	10.95
73	72.29	10.16	72.24	10.48	72.20	10.79	72.15	11.11
74	73.28	10.30	73.23	10.62	73.19	10.94	73.14	11.26
75	74.27	10.44	74.22	10.76	74.18	11.09	74.13	11.41
76	75.26	10.58	75.21	10.91	75.17	11.23	75.12	11.56
77	76.25	10.72	76.20	11.05	76.15	11.38	76.10	11.71
78	77.24	10.86	77.19	11.19	77.14	11.53	77.09	11.87
79	78.23	10.99	78.18	11.34	78.13	11.68	78.08	12.02
80	79.22	11.13	79.17	11.48	79.12	11.82	79.07	12.17
81	80.21	11.27	80.16	11.62	80.11	11.97	80.06	12.32
82	81.20	11.41	81.15	11.77	81.10	12.12	81.05	12.47
83	82.19	11.55	82.14	11.91	82.09	12.27	82.03	12.63
84	83.18	11.69	83.13	12.05	83.08	12.42	83.02	12.78
85	84.17	11.83	84.12	12.20	84.07	12.56	84.01	12.93
86	85.16	11.97	85.11	12.34	85.06	12.71	85.00	13.08
87	86.15	12.11	86.10	12.48	86.04	12.86	85.99	13.23
88	87.14	12.25	87.09	12.63	87.03	13.01	86.98	13.39
89	88.13	12.39	88.08	12.77	88.02	13.16	87.96	13.54
90	89.12	12.53	89.07	12.91	89.01	13.30	88.95	13.69
91	90.11	12.66	90.06	13.06	90.00	13.45	89.94	13.84
92	91.10	12.80	91.05	13.20	90.99	13.60	90.93	14.00
93	92.09	12.94	92.04	13.34	91.98	13.75	91.92	14.15
94	93.09	13.08	93.03	13.49	92.97	13.89	92.91	14.30
95	94.08	13.22	94.02	13.63	93.96	14.04	93.89	14.45
96	95.07	13.36	95.01	13.78	94.95	14.19	94.88	14.60
97	96.06	13.50	96.00	13.92	95.93	14.34	95.87	14.76
98	97.05	13.64	96.99	14.06	96.92	14.49	96.86	14.91
99	98.04	13.78	97.98	14.21	97.91	14.63	97.85	15.06
100	99.03	13.92	98.97	14.35	98.90	14.78	98.84	15.21
101	100.0	14.06	99.95	14.49	99.89	14.93	99.82	15.36
102	101.0	14.20	100.9	14.64	100.9	15.08	100.8	15.52
103	102.0	14.33	101.9	14.78	101.9	15.22	101.8	15.67
104	103.0	14.47	102.9	14.92	102.9	15.37	102.8	15.82
105	104.0	14.61	103.9	15.07	103.8	15.52	103.8	15.97
106	105.0	14.75	104.9	15.21	104.8	15.67	104.8	16.13
107	106.0	14.89	105.9	15.35	105.8	15.82	105.8	16.28
108	106.9	15.03	106.9	15.50	106.8	15.96	106.7	16.43
109	107.9	15.17	107.9	15.64	107.8	16.11	107.7	16.58
110	108.9	15.31	108.9	15.78	108.8	16.26	108.7	16.73
111	109.9	15.45	109.9	15.93	109.8	16.41	109.7	16.89
112	110.9	15.59	110.8	16.07	110.8	16.55	110.7	17.04
113	111.9	15.73	111.8	16.21	111.8	16.70	111.7	17.19
114	112.9	15.87	112.8	16.36	112.7	16.85	112.7	17.34
115	113.9	16.00	113.8	16.50	113.7	17.00	113.7	17.49
116	114.9	16.14	114.8	16.65	114.7	17.15	114.7	17.65
117	115.9	16.28	115.8	16.79	115.7	17.29	115.6	17.80
118	116.9	16.42	116.8	16.93	116.7	17.44	116.6	17.95
119	117.8	16.56	117.8	17.08	117.7	17.59	117.6	18.10
120	118.8	16.70	118.8	17.22	118.7	17.74	118.6	18.25
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
1	0.99	0.16	0.99	0.16	0.99	0.17	0.99	0.17
2	1.98	0.31	1.97	0.32	1.97	0.33	1.97	0.34
3	2.96	0.47	2.96	0.48	2.96	0.50	2.96	0.51
4	3.95	0.63	3.95	0.64	3.95	0.66	3.94	0.68
5	4.94	0.78	4.94	0.80	4.93	0.83	4.93	0.85
6	5.93	0.94	5.92	0.96	5.92	0.99	5.91	1.02
7	6.91	1.10	6.91	1.13	6.90	1.16	6.90	1.19
8	7.90	1.25	7.90	1.29	7.89	1.32	7.88	1.35
9	8.89	1.41	8.88	1.45	8.88	1.49	8.87	1.52
10	9.88	1.56	9.87	1.61	9.86	1.65	9.86	1.69
11	10.86	1.72	10.86	1.77	10.85	1.82	10.84	1.86
12	11.85	1.88	11.84	1.93	11.84	1.98	11.83	2.03
13	12.84	2.03	12.83	2.09	12.82	2.15	12.81	2.20
14	13.83	2.19	13.82	2.25	13.81	2.31	13.80	2.37
15	14.82	2.35	14.80	2.41	14.79	2.48	14.78	2.54
16	15.80	2.50	15.79	2.57	15.78	2.64	15.77	2.71
17	16.79	2.66	16.78	2.73	16.77	2.81	16.75	2.88
18	17.78	2.82	17.77	2.89	17.75	2.97	17.74	3.05
19	18.77	2.97	18.75	3.05	18.74	3.14	18.73	3.22
20	19.75	3.13	19.74	3.21	19.73	3.30	19.71	3.39
21	20.74	3.29	20.73	3.38	20.71	3.47	20.70	3.56
22	21.73	3.44	21.71	3.54	21.70	3.63	21.68	3.73
23	22.72	3.60	22.70	3.70	22.68	3.80	22.67	3.90
24	23.70	3.75	23.69	3.86	23.67	3.96	23.65	4.06
25	24.69	3.91	24.67	4.02	24.66	4.13	24.64	4.23
26	25.68	4.07	25.66	4.18	25.64	4.29	25.62	4.40
27	26.67	4.22	26.65	4.34	26.63	4.46	26.61	4.57
28	27.66	4.38	27.64	4.50	27.62	4.62	27.60	4.74
29	28.64	4.54	28.62	4.66	28.60	4.79	28.58	4.91
30	29.63	4.69	29.61	4.82	29.59	4.95	29.57	5.08
31	30.62	4.85	30.60	4.98	30.57	5.12	30.55	5.25
32	31.61	5.01	31.58	5.14	31.56	5.28	31.54	5.42
33	32.59	5.16	32.57	5.30	32.55	5.45	32.52	5.59
34	33.58	5.32	33.56	5.47	33.53	5.61	33.51	5.76
35	34.57	5.48	34.54	5.63	34.52	5.78	34.49	5.93
36	35.56	5.63	35.53	5.79	35.51	5.94	35.48	6.10
37	36.54	5.79	36.52	5.95	36.49	6.11	36.47	6.27
38	37.53	5.94	37.51	6.11	37.48	6.27	37.45	6.44
39	38.52	6.10	38.49	6.27	38.47	6.44	38.44	6.60
40	39.51	6.26	39.48	6.43	39.45	6.60	39.42	6.77
41	40.50	6.41	40.47	6.59	40.44	6.77	40.41	6.94
42	41.48	6.57	41.45	6.75	41.42	6.93	41.39	7.11
43	42.47	6.73	42.44	6.91	42.41	7.10	42.38	7.28
44	43.46	6.88	43.43	7.07	43.40	7.26	43.36	7.45
45	44.45	7.04	44.41	7.23	44.38	7.43	44.35	7.62
46	45.43	7.20	45.40	7.39	45.37	7.59	45.34	7.79
47	46.42	7.35	46.39	7.55	46.36	7.76	46.32	7.96
48	47.41	7.51	47.38	7.72	47.34	7.92	47.31	8.13
49	48.40	7.66	48.36	7.88	48.33	8.09	48.29	8.30
50	49.38	7.82	49.35	8.04	49.31	8.25	49.28	8.47
51	50.37	7.98	50.34	8.20	50.30	8.42	50.26	8.64
52	51.36	8.13	51.32	8.36	51.29	8.58	51.25	8.81
53	52.35	8.29	52.31	8.52	52.27	8.75	52.23	8.98
54	53.34	8.45	53.30	8.68	53.26	8.91	53.22	9.14
55	54.32	8.60	54.28	8.84	54.25	9.08	54.21	9.31
56	55.31	8.76	55.27	9.00	55.23	9.24	55.19	9.48
57	56.30	8.92	56.26	9.16	56.22	9.41	56.18	9.65
58	57.29	9.07	57.25	9.32	57.20	9.57	57.16	9.82
59	58.27	9.23	58.23	9.48	58.19	9.74	58.15	9.99
60	59.26	9.39	59.22	9.64	59.18	9.90	59.13	10.16
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′		15′		30′		45′	
	Lat	Dep.	Lat.	Dep	Lat	Dep.	Lat	Dep
61	60.25	9.54	60.21	9.81	60.16	10.07	60.12	10.33
62	61.24	9.70	61.19	9.97	61.15	10.23	61.10	10.50
63	62.22	9.86	62.18	10.13	62.14	10.40	62.09	10.67
64	63.21	10.01	63.17	10.29	63.12	10.56	63.08	10.84
65	64.20	10.17	64.15	10.45	64.11	10.73	64.06	11.01
66	65.19	10.32	65.14	10.61	65.09	10.89	65.05	11.18
67	66.18	10.48	66.13	10.77	66.08	11.06	66.03	11.35
68	67.16	10.64	67.12	10.93	67.07	11.22	67.02	11.52
69	68.15	10.79	68.10	11.09	68.05	11.39	68.00	11.69
70	69.14	10.95	69.09	11.25	69.04	11.55	68.99	11.85
71	70.13	11.11	70.08	11.41	70.03	11.72	69.97	12.02
72	71.11	11.26	71.06	11.57	71.01	11.88	70.96	12.19
73	72.10	11.42	72.05	11.73	72.00	12.05	71.95	12.36
74	73.09	11.58	73.04	11.90	72.99	12.21	72.93	12.53
75	74.08	11.73	74.02	12.06	73.97	12.38	73.92	12.70
76	75.06	11.89	75.01	12.22	74.96	12.54	74.90	12.87
77	76.05	12.05	76.00	12.38	75.94	12.71	75.89	13.04
78	77.04	12.20	76.99	12.54	76.93	12.87	76.87	13.21
79	78.03	12.36	77.97	12.70	77.92	13.04	77.86	13.38
80	79.02	12.51	78.96	12.86	78.90	13.20	78.84	13.55
81	80.00	12.67	79.95	13.02	79.89	13.37	79.83	13.72
82	80.99	12.83	80.93	13.18	80.88	13.53	80.82	13.89
83	81.98	12.98	81.92	13.34	81.86	13.70	81.80	14.06
84	82.97	13.14	82.91	13.50	82.85	13.86	82.79	14.23
85	83.95	13.30	83.89	13.66	83.83	14.03	83.77	14.39
86	84.94	13.45	84.88	13.82	84.82	14.19	84.76	14.56
87	85.93	13.61	85.87	13.98	85.81	14.36	85.74	14.73
88	86.92	13.77	86.86	14.15	86.79	14.52	86.73	14.90
89	87.90	13.92	87.84	14.31	87.78	14.69	87.71	15.07
90	88.89	14.08	88.83	14.47	88.77	14.85	88.70	15.24
91	89.88	14.24	89.82	14.63	89.75	15.02	89.69	15.41
92	90.87	14.39	90.80	14.79	90.74	15.18	90.67	15.58
93	91.86	14.55	91.79	14.95	91.72	15.35	91.66	15.75
94	92.84	14.70	92.78	15.11	92.71	15.51	92.64	15.92
95	93.83	14.86	93.76	15.27	93.70	15.68	93.63	16.09
96	94.82	15.02	94.75	15.43	94.68	15.84	94.61	16.26
97	95.81	15.17	95.74	15.59	95.67	16.01	95.60	16.43
98	96.79	15.33	96.73	15.75	96.66	16.17	96.58	16.60
99	97.78	15.49	97.71	15.91	97.64	16.34	97.57	16.77
100	98.77	15.64	98.70	16.07	98.63	16.50	98.56	16.94
101	99.76	15.80	99.69	16.24	99.61	16.67	99.54	17.10
102	100.7	15.96	100.7	16.40	100.6	16.83	100.5	17.27
103	101.7	16.11	101.7	16.56	101.6	17.00	101.5	17.44
104	102.7	16.27	102.6	16.72	102.6	17.17	102.5	17.61
105	103.7	16.43	103.6	16.88	103.6	17.33	103.5	17.78
106	104.7	16.58	104.6	17.04	104.5	17.50	104.5	17.95
107	105.7	16.74	105.6	17.20	105.5	17.66	105.5	18.12
108	106.7	16.90	106.6	17.36	106.5	17.83	106.4	18.29
109	107.7	17.05	107.6	17.52	107.5	17.99	107.4	18.46
110	108.6	17.21	108.6	17.68	108.5	18.16	108.4	18.6[illegible]
111	109.6	17.36	109.6	17.84	109.5	18.32	109.4	18.8[illegible]
112	110.6	17.52	110.5	18.00	110.5	18.49	110.4	18.97
113	111.6	17.68	111.5	18.16	111.5	18.65	111.4	19.14
114	112.6	17.83	112.5	18.32	112.4	18.82	112.4	19.31
115	113.6	17.99	113.5	18.49	113.4	18.98	113.3	19.4[illegible]
116	114.6	18.15	114.5	18.65	114.4	19.15	114.3	19.[illegible]
117	115.6	18.30	115.5	18.81	115.4	19.31	115.3	19.[illegible]
118	116.5	18.46	116.5	18.97	116.4	19.48	116.3	19.[illegible]
119	117.5	18.62	117.5	19.13	117.4	19.64	117.3	20.[illegible]
120	118.5	18.77	118.4	19.29	118.4	19.80	118.3	20.[illegible]
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	L[illegible]
	0′		45′		30′		15′	

Dist.	0' Lat.	0' Dep.	15' Lat.	15' Dep.	30' Lat.	30' Dep.	45' Lat.	45' Dep.
1	0.98	0.17	0.98	0.18	0.98	0.18	0.98	0.19
2	1.97	0.35	1.97	0.36	1.97	0.36	1.96	0.37
3	2.95	0.52	2.95	0.53	2.95	0.55	2.95	0.56
4	3.94	0.69	3.94	0.71	3.93	0.73	3.93	0.75
5	4.92	0.87	4.92	0.89	4.92	0.91	4.91	0.93
6	5.91	1.04	5.90	1.07	5.90	1.09	5.89	1.12
7	6.89	1.22	6.89	1.25	6.88	1.28	6.88	1.31
8	7.88	1.39	7.87	1.42	7.87	1.46	7.86	1.49
9	8.86	1.56	8.86	1.60	8.85	1.64	8.84	1.68
10	9.85	1.74	9.84	1.78	9.83	1.82	9.82	1.87
11	10.83	1.91	10.82	1.96	10.82	2.00	10.81	2.05
12	11.82	2.08	11.81	2.14	11.80	2.19	11.79	2.24
13	12.80	2.26	12.79	2.31	12.78	2.37	12.77	2.42
14	13.79	2.43	13.78	2.49	13.77	2.55	13.75	2.61
15	14.77	2.60	14.76	2.67	14.75	2.73	14.74	2.30
16	15.76	2.78	15.74	2.85	15.73	2.92	15.72	2.98
17	16.74	2.95	16.73	3.03	16.72	3.10	16.70	3.17
18	17.73	3.13	17.71	3.20	17.70	3.28	17.68	3.36
19	18.71	3.30	18.70	3.38	18.68	3.46	18.67	3.54
20	19.70	3.47	19.68	3.56	19.67	3.64	19.65	3.73
21	20.68	3.65	20.66	3.74	20.65	3.83	20.63	3.92
22	21.67	3.82	21.65	3.91	21.63	4.01	21.61	4.10
23	22.65	3.99	22.63	4.09	22.61	4.19	22.60	4.29
24	23.64	4.17	23.62	4.27	23.60	4.37	23.58	4.48
25	24.62	4.34	24.60	4.45	24.58	4.56	24.56	4.66
26	25.61	4.51	25.59	4.63	25.56	4.74	25.54	4.85
27	26.59	4.69	26.57	4.80	26.55	4.92	26.53	5.04
28	27.57	4.86	27.55	4.98	27.53	5.10	27.51	5.22
29	28.56	5.04	28.54	5.16	28.51	5.28	28.49	5.41
30	29.54	5.21	29.52	5.34	29.50	5.47	29.47	5.60
31	30.53	5.38	30.51	5.52	30.48	5.65	30.46	5.78
32	31.51	5.56	31.49	5.69	31.46	5.83	31.44	5.97
33	32.50	5.73	32.47	5.87	32.45	6.01	32.42	6.16
34	33.48	5.90	33.46	6.05	33.43	6.20	33.40	6.34
35	34.47	6.08	34.44	6.23	34.41	6.38	34.39	6.53
36	35.45	6.25	35.43	6.41	35.40	6.56	35.37	6.71
37	36.44	6.43	36.41	6.58	36.38	6.74	36.35	6.90
38	37.42	6.60	37.39	6.76	37.36	6.92	37.33	7.09
39	38.41	6.77	38.38	6.94	38.35	7.11	38.32	7.27
40	39.39	6.95	39.36	7.12	39.33	7.29	39.30	7.46
41	40.38	7.12	40.35	7.30	40.31	7.47	40.28	7.65
42	41.36	7.29	41.33	7.47	41.30	7.65	41.26	7.83
43	42.35	7.47	42.31	7.65	42.28	7.84	42.25	8.02
44	43.33	7.64	43.30	7.83	43.26	8.02	43.22	8.21
45	44.32	7.81	44.28	8.01	44.25	8.20	44.21	8.39
46	45.30	7.99	45.27	8.19	45.23	8.38	45.19	8.58
47	46.29	8.16	46.25	8.36	46.21	8.57	46.18	8.77
48	47.27	8.34	47.23	8.54	47.20	8.75	47.16	8.95
49	48.26	8.51	48.22	8.72	48.18	8.93	48.14	9.14
50	49.24	8.68	49.20	8.90	49.16	9.11	49.12	9.33
51	50.23	8.86	50.19	9.08	50.15	9.29	50.11	9.51
52	51.21	9.03	51.17	9.25	51.13	9.48	51.09	9.70
53	52.19	9.20	52.15	9.43	52.11	9.66	52.07	9.89
54	53.18	9.38	53.14	9.61	53.10	9.84	53.05	10.07
55	54.16	9.55	54.12	9.79	54.08	10.02	54.03	10.26
56	55.15	9.72	55.11	9.96	55.06	10.21	55.02	10.45
57	56.13	9.90	56.09	10.14	56.05	10.39	56.00	10.63
58	57.12	10.07	57.07	10.32	57.03	10.57	56.98	10.82
59	58.10	10.25	58.06	10.50	58.01	10.75	57.96	11.00
60	59.09	10.42	59.04	10.68	59.00	10.93	58.95	11.19
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0'		45'		30'		15'	

79 DEGREES.

Dist.	0' Lat.	0' Dep.	15' Lat.	15' Dep.	30' Lat.	30' Dep.	45' Lat.	45' Dep.
61	60.07	10.59	60.03	10.85	59.98	11.12	59.93	11.38
62	61.06	10.77	61.01	11.03	60.96	11.30	60.91	11.56
63	62.04	10.94	61.99	11.21	61.95	11.48	61.89	11.75
64	63.03	11.11	62.98	11.39	62.93	11.66	62.88	11.94
65	64.01	11.29	63.96	11.57	63.91	11.85	63.86	12.12
66	65.00	11.46	64.95	11.74	64.89	12.03	64.84	12.31
67	65.98	11.63	65.93	11.92	65.88	12.21	65.82	12.50
68	66.97	11.81	66.91	12.10	66.86	12.39	66.81	12.68
69	67.95	11.98	67.90	12.28	67.84	12.57	67.79	12.87
70	68.94	12.16	68.88	12.46	68.83	12.76	68.77	13.06
71	69.92	12.33	69.87	12.63	69.81	12.94	69.75	13.24
72	70.91	12.50	70.85	12.81	70.79	13.12	70.74	13.43
73	71.89	12.68	71.84	12.99	71.78	13.30	71.72	13.62
74	72.88	12.85	72.82	13.17	72.76	13.49	72.70	13.80
75	73.86	13.02	73.80	13.35	73.74	13.67	73.68	13.90
76	74.85	13.20	74.79	13.52	74.73	13.85	74.67	14.18
77	75.83	13.37	75.77	13.70	75.71	14.03	75.65	14.36
78	76.82	13.54	76.76	13.88	76.69	14.21	76.63	14.55
79	77.80	13.72	77.74	14.06	77.68	14.40	77.61	14.74
80	78.78	13.89	78.72	14.24	78.66	14.58	78.60	14.92
81	79.77	14.07	79.71	14.41	79.64	14.76	79.58	15.11
82	80.75	14.24	80.69	14.59	80.63	14.94	80.56	15.30
83	81.74	14.41	81.68	14.77	81.61	15.13	81.54	15.48
84	82.72	14.59	82.66	14.95	82.59	15.31	82.53	15.67
85	83.71	14.76	83.64	15.13	83.58	15.49	83.51	15.85
86	84.69	14.93	84.63	15.30	84.56	15.67	84.49	16.04
87	85.68	15.11	85.61	15.48	85.54	15.85	85.47	16.23
88	86.66	15.28	86.60	15.66	86.53	16.04	86.46	16.41
89	87.65	15.45	87.58	15.84	87.51	16.22	87.44	16.60
90	88.63	15.63	88.56	16.01	88.49	16.40	88.42	16.79
91	89.62	15.80	89.55	16.19	89.48	16.58	89.40	16.97
92	90.60	15.98	90.53	16.37	90.46	16.77	90.39	17.16
93	91.59	16.15	91.52	16.55	91.44	16.95	91.37	17.35
94	92.57	16.32	92.50	16.73	92.43	17.13	92.35	17.53
95	93.56	16.50	93.48	16.90	93.41	17.31	93.33	17.72
96	94.54	16.67	94.47	17.08	94.39	17.49	94.32	17.91
97	95.53	16.84	95.45	17.26	95.38	17.68	95.30	18.09
98	96.51	17.02	96.44	17.44	96.36	17.86	96.28	18.28
99	97.50	17.19	97.42	17.62	97.34	18.04	97.26	18.47
100	98.48	17.36	98.40	17.79	98.33	18.22	98.25	18.63
101	99.47	17.54	99.39	17.97	99.31	18.41	99.23	18.84
102	100.4	17.71	100.4	18.15	100.3	18.59	100.2	19.03
103	101.4	17.89	101.4	18.33	101.3	18.77	101.2	19.21
104	102.4	18.06	102.3	18.51	102.3	18.95	102.2	19.40
105	103.4	18.23	103.3	18.68	103.2	19.13	103.2	19.59
106	104.4	18.41	104.3	18.86	104.2	19.32	104.1	19.77
107	105.4	18.58	105.3	19.04	105.2	19.50	105.1	19.96
108	106.4	18.75	106.3	19.22	106.2	19.68	106.1	20.14
109	107.3	18.93	107.3	19.40	107.2	19.86	107.1	20.32
110	108.3	19.10	108.2	19.57	108.2	20.05	108.1	20.52
111	109.3	19.28	109.2	19.75	109.1	20.23	109.1	20.70
112	110.3	19.45	110.2	19.93	110.1	20.41	110.0	20.89
113	111.3	19.62	111.2	20.11	111.1	20.59	111.0	21.08
114	112.3	19.80	112.2	20.29	112.1	20.77	112.0	21.26
115	113.3	19.97	113.2	20.46	113.1	20.96	113.0	21.45
116	114.2	20.14	114.1	20.64	114.1	21.14	114.0	21.60
117	115.2	20.32	115.1	20.82	115.0	21.32	114.9	21.82
118	116.2	20.49	116.1	21.00	116.0	21.50	115.9	22.01
119	117.2	20.66	117.1	21.18	117.0	21.69	116.9	22.20
120	118.2	20.84	118.1	21.35	118.0	21.87	117.9	22.38
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0'		45'		30'		15'	

79 DEGREES.

Dist.	0′ Lat	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat	30′ Dep.	45′ Lat.	45′ Dep
1	0.98	0.19	0.98	0.20	0.98	0.20	0.98	0.20
2	1.96	0.38	1.96	0.39	1.96	0.40	1.96	0.41
3	2.94	0.57	2.94	0.59	2.94	0.60	2.94	0.61
4	3.93	0.76	3.92	0.78	3.92	0.80	3.92	0.81
5	4.91	0.95	4.90	0.98	4.90	1.00	4.90	1.02
6	5.89	1.14	5.88	1.17	5.88	1.20	5.87	1.22
7	6.87	1.34	6.87	1.37	6.86	1.40	6.85	1.43
8	7.85	1.53	7.85	1.56	7.84	1.59	7.83	1.63
9	8.83	1.72	8.83	1.76	8.82	1.79	8.81	1.83
10	9.82	1.91	9.81	1.95	9.80	1.99	9.79	2.04
11	10.80	2.10	10.79	2.15	10.78	2.19	10.77	2.24
12	11.78	2.29	11.77	2.34	11.76	2.39	11.75	2.44
13	12.76	2.48	12.75	2.54	12.74	2.59	12.73	2.65
14	13.74	2.67	13.73	2.73	13.72	2.79	13.71	2.85
15	14.72	2.86	14.71	2.93	14.70	2.99	14.69	3.05
16	15.71	3.05	15.69	3.12	15.68	3.19	15.66	3.26
17	16.69	3.24	16.67	3.32	16.66	3.39	16.64	3.46
18	17.67	3.43	17.65	3.51	17.64	3.59	17.62	3.67
19	18.65	3.63	18.63	3.71	18.62	3.79	18.60	3.87
20	19.63	3.82	19.62	3.90	19.60	3.99	19.58	4.07
21	20.61	4.01	20.60	4.10	20.58	4.19	20.56	4.28
22	21.60	4.20	21.58	4.29	21.56	4.39	21.54	4.48
23	22.58	4.39	22.56	4.49	22.54	4.59	22.52	4.68
24	23.56	4.58	23.54	4.68	23.52	4.78	23.50	4.89
25	24.54	4.77	24.52	4.88	24.50	4.98	24.48	5.09
26	25.52	4.96	25.50	5.07	25.48	5.18	25.46	5.29
27	26.50	5.15	26.48	5.27	26.46	5.38	26.43	5.50
28	27.49	5.34	27.46	5.46	27.44	5.58	27.41	5.70
29	28.47	5.53	28.44	5.66	28.42	5.78	28.39	5.91
30	29.45	5.72	29.42	5.85	29.40	5.98	29.37	6.11
31	30.43	5.92	30.40	6.05	30.38	6.18	30.35	6.31
32	31.41	6.11	31.39	6.24	31.36	6.38	31.33	6.52
33	32.39	6.30	32.37	6.44	32.34	6.58	32.31	6.72
34	33.38	6.49	33.35	6.63	33.32	6.78	33.29	6.92
35	34.36	6.68	34.33	6.83	34.30	6.98	34.27	7.13
36	35.34	6.87	35.31	7.02	35.28	7.18	35.25	7.33
37	36.32	7.06	36.29	7.22	36.26	7.38	36.22	7.53
38	37.30	7.25	37.27	7.41	37.24	7.58	37.20	7.74
39	38.28	7.44	38.25	7.61	38.22	7.78	38.18	7.94
40	39.27	7.63	39.23	7.80	39.20	7.97	39.16	8.15
41	40.25	7.82	40.21	8.00	40.18	8.17	40.14	8.35
42	41.23	8.01	41.19	8.19	41.16	8.37	41.12	8.55
43	42.21	8.20	42.17	8.39	42.14	8.57	42.10	8.76
44	43.19	8.40	43.15	8.58	43.12	8.77	43.08	8.96
45	44.17	8.59	44.14	8.78	44.10	8.97	44.06	9.16
46	45.15	8.78	45.12	8.97	45.08	9.17	45.04	9.37
47	46.14	8.97	46.10	9.17	46.06	9.37	46.02	9.57
48	47.12	9.16	47.08	9.36	47.04	9.57	46.99	9.77
49	48.10	9.35	48.06	9.56	48.02	9.77	47.97	9.98
50	49.08	9.54	49.04	9.75	49.00	9.97	48.95	10.18
51	50.06	9.73	50.02	9.95	49.98	10.17	49.93	10.39
52	51.04	9.92	51.00	10.14	50.96	10.37	50.91	10.59
53	52.03	10.11	51.98	10.34	51.94	10.57	51.89	10.79
54	53.01	10.30	52.96	10.53	52.92	10.77	52.87	11.00
55	53.99	10.49	53.94	10.73	53.90	10.97	53.85	11.20
56	54.97	10.69	54.92	10.93	54.88	11.16	54.83	11.40
57	55.95	10.88	55.90	11.12	55.86	11.36	55.81	11.61
58	56.93	11.07	56.89	11.32	56.84	11.56	56.78	11.81
59	57.92	11.26	57.87	11.51	57.82	11.76	57.76	12.01
60	58.90	11.45	58.85	11.71	58.80	11.96	58.74	12.22
Dist.	Dep	Lat.	Dep.	Lat	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

78 DEGREES.

Dist.	0′ Lat.	Dep.	15′ Lat	Dep	30′ Lat.	Dep.	45′ Lat.	Dep.
61	59.88	11.64	59.83	11.90	59.78	12.16	59.72	12.42
62	60.86	11.83	60.81	12.10	60.76	12.36	60.70	12.63
63	61.84	12.02	61.79	12.29	61.74	12.56	61.68	12.83
64	62.82	12.21	62.77	12.49	62.72	12.76	62.66	13.03
65	63.81	12.40	63.75	12.68	63.70	12.96	63.64	13.24
66	64.79	12.59	64.73	12.88	64.68	13.16	64.62	13.44
67	65.77	12.78	65.71	13.07	65.66	13.36	65.60	13.64
68	66.75	12.98	66.69	13.27	66.63	13.56	66.58	13.85
69	67.73	13.17	67.67	13.46	67.61	13.76	67.55	14.05
70	68.71	13.36	68.66	13.66	68.59	13.96	68.53	14.25
71	69.70	13.55	69.64	13.85	69.57	14.16	69.51	14.46
72	70.68	13.74	70.62	14.05	70.55	14.35	70.49	14.66
73	71.66	13.93	71.60	14.24	71.53	14.55	71.47	14.87
74	72.64	14.12	72.58	14.44	72.51	14.75	72.45	15.07
75	73.62	14.31	73.56	14.63	73.49	14.95	73.43	15.27
76	74.60	14.50	74.54	14.83	74.47	15.15	74.41	15.48
77	75.59	14.69	75.52	15.02	75.45	15.35	75.39	15.68
78	76.57	14.88	76.50	15.22	76.43	15.55	76.37	15.88
79	77.55	15.07	77.48	15.41	77.41	15.75	77.34	16.09
80	78.53	15.26	78.46	15.61	78.39	15.95	78.32	16.29
81	79.51	15.46	79.44	15.80	79.37	16.15	79.30	16.50
82	80.49	15.65	80.42	16.00	80.35	16.35	80.28	16.70
83	81.48	15.84	81.41	16.19	81.33	16.55	81.26	16.90
84	82.46	16.03	82.39	16.39	82.31	16.75	82.24	17.11
85	83.44	16.22	83.37	16.58	83.29	16.95	83.22	17.31
86	84.42	16.41	84.35	16.78	84.27	17.15	84.20	17.51
87	85.40	16.60	85.33	16.97	85.25	17.35	85.18	17.72
88	86.38	16.79	86.31	17.17	86.23	17.54	86.16	17.92
89	87.36	16.98	87.29	17.36	87.21	17.74	87.14	18.12
90	88.35	17.17	88.27	17.56	88.19	17.94	88.11	18.33
91	89.33	17.38	89.25	17.75	89.17	18.14	89.09	18.53
92	90.31	17.55	90.23	17.95	90.15	18.34	90.07	18.74
93	91.29	17.75	91.21	18.14	91.13	18.54	91.05	18.94
94	92.27	17.94	92.19	18.34	92.11	18.74	92.03	19.14
95	93.25	18.13	93.17	18.53	93.09	18.94	93.01	19.35
96	94.24	18.32	94.16	18.73	94.07	19.14	93.99	19.55
97	95.22	18.51	95.14	18.92	95.05	19.34	94.97	19.75
98	96.20	18.70	96.12	19.12	96.03	19.54	95.95	19.96
99	97.18	18.89	97.10	19.31	97.01	19.74	96.93	20.16
100	98.16	19.08	98.08	19.51	97.99	19.94	97.90	20.36
101	99.14	19.27	99.06	19.70	98.97	20.14	98.88	20.57
102	100.1	19.46	100.0	19.90	99.95	20.34	99.86	20.77
103	101.1	19.65	101.0	20.09	100.9	20.53	100.8	20.98
104	102.1	19.84	102.0	20.29	101.9	20.73	101.8	21.18
105	103.1	20.04	103.0	20.48	102.9	20.93	102.8	21.38
106	104.1	20.23	104.0	20.68	103.9	21.13	103.8	21.59
107	105.0	20.42	104.9	20.87	104.9	21.33	104.8	21.79
108	106.0	20.61	105.9	21.07	105.8	21.53	105.7	21.99
109	107.0	20.80	106.9	21.26	106.8	21.73	106.7	22.20
110	108.0	20.99	107.9	21.46	107.8	21.93	107.7	22.40
111	109.0	21.18	108.9	21.66	108.8	22.13	108.7	22.60
112	119.9	21.37	109.8	21.85	109.8	22.33	109.7	22.81
113	110.9	21.56	110.8	22.05	110.7	22.53	110.6	23.01
114	111.9	21.75	111.8	22.24	111.7	22.73	111.6	23.22
115	112.9	21.94	112.8	22.44	112.7	22.93	112.6	23.42
116	113.9	22.12	113.8	22.63	113.7	23.13	113.6	23.62
117	114.9	22.32	114.7	22.83	114.6	23.33	114.5	23.83
118	115.8	22.52	115.7	23.02	115.6	23.53	115.5	24.03
119	116.8	22.71	116.7	23.22	116.6	23.72	116.5	24.23
120	117.8	22.90	117.7	23.41	117.6	23.92	117.5	24.44
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′				30′		15′	

Dist.	0′ Lat	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat	30′ Dep.	45′ Lat.	45′ Dep
1	0.98	0.19	0.98	0.20	0.98	0.20	0.98	0.20
2	1.96	0.38	1.96	0.39	1.96	0.40	1.96	0.41
3	2.94	0.57	2.94	0.59	2.94	0.60	2.94	0.61
4	3.93	0.76	3.92	0.78	3.92	0.80	3.92	0.81
5	4.91	0.95	4.90	0.98	4.90	1.00	4.90	1.02
6	5.89	1.14	5.88	1.17	5.88	1.20	5.87	1.22
7	6.87	1.34	6.87	1.37	6.86	1.40	6.85	1.43
8	7.85	1.53	7.85	1.56	7.84	1.59	7.83	1.63
9	8.83	1.72	8.83	1.76	8.82	1.79	8.81	1.83
10	9.82	1.91	9.81	1.95	9.80	1.99	9.79	2.04
11	10.80	2.10	10.79	2.15	10.78	2.19	10.77	2.24
12	11.78	2.29	11.77	2.34	11.76	2.39	11.75	2.44
13	12.76	2.48	12.75	2.54	12.74	2.59	12.73	2.65
14	13.74	2.67	13.73	2.73	13.72	2.79	13.71	2.85
15	14.72	2.86	14.71	2.93	14.70	2.99	14.69	3.05
16	15.71	3.05	15.69	3.12	15.68	3.19	15.66	3.26
17	16.69	3.24	16.67	3.32	16.66	3.39	16.64	3.46
18	17.67	3.43	17.65	3.51	17.64	3.59	17.62	3.67
19	18.65	3.63	18.63	3.71	18.62	3.79	18.60	3.87
20	19.63	3.82	19.62	3.90	19.60	3.99	19.58	4.07
21	20.61	4.01	20.60	4.10	20.58	4.19	20.56	4.28
22	21.60	4.20	21.58	4.29	21.56	4.39	21.54	4.48
23	22.58	4.39	22.56	4.49	22.54	4.59	22.52	4.68
24	23.56	4.58	23.54	4.68	23.52	4.78	23.50	4.89
25	24.54	4.77	24.52	4.88	24.50	4.98	24.48	5.09
26	25.52	4.96	25.50	5.07	25.48	5.18	25.46	5.29
27	26.50	5.15	26.48	5.27	26.46	5.38	26.43	5.50
28	27.49	5.34	27.46	5.46	27.44	5.58	27.41	5.70
29	28.47	5.53	28.44	5.66	28.42	5.78	28.39	5.91
30	29.45	5.72	29.42	5.85	29.40	5.98	29.37	6.11
31	30.43	5.92	30.40	6.05	30.38	6.18	30.35	6.31
32	31.41	6.11	31.39	6.24	31.36	6.38	31.33	6.52
33	32.39	6.30	32.37	6.44	32.34	6.58	32.31	6.72
34	33.38	6.49	33.35	6.63	33.32	6.78	33.29	6.92
35	34.36	6.68	34.33	6.83	34.30	6.98	34.27	7.13
36	35.34	6.87	35.31	7.02	35.28	7.18	35.25	7.33
37	36.32	7.06	36.29	7.22	36.26	7.38	36.22	7.53
38	37.30	7.25	37.27	7.41	37.24	7.58	37.26	7.74
39	38.28	7.44	38.25	7.61	38.22	7.78	38.18	7.94
40	39.27	7.63	39.23	7.80	39.20	7.97	39.16	8.15
41	40.25	7.82	40.21	8.00	40.18	8.17	40.14	8.35
42	41.23	8.01	41.19	8.19	41.16	8.37	41.12	8.55
43	42.21	8.20	42.17	8.39	42.14	8.57	42.10	8.76
44	43.19	8.40	43.15	8.58	43.12	8.77	43.08	8.96
45	44.17	8.59	44.14	8.78	44.10	8.97	44.06	9.16
46	45.15	8.78	45.12	8.97	45.08	9.17	45.04	9.37
47	46.14	8.97	46.10	9.17	46.06	9.37	46.02	9.57
48	47.12	9.16	47.08	9.36	47.04	9.57	46.99	9.77
49	48.10	9.35	48.06	9.56	48.02	9.77	47.97	9.98
50	49.08	9.54	49.04	9.75	49.00	9.97	48.95	10.18
51	50.06	9.73	50.02	9.95	49.98	10.17	49.93	10.39
52	51.04	9.92	51.00	10.14	50.96	10.37	50.91	10.59
53	52.03	10.11	51.98	10.34	51.94	10.57	51.89	10.79
54	53.01	10.30	52.96	10.53	52.92	10.77	52.87	11.00
55	53.99	10.49	53.94	10.73	53.90	10.97	53.85	11.20
56	54.97	10.69	54.92	10.93	54.88	11.16	54.83	11.40
57	55.95	10.88	55.90	11.12	55.86	11.36	55.81	11.61
58	56.93	11.07	56.89	11.32	56.84	11.56	56.78	11.81
59	57.92	11.26	57.87	11.51	57.82	11.76	57.76	12.01
60′	58.90	11.45	58.85	11.71	58.80	11.96	58.74	12.22
Dist	Dep 0′	Lat 0′	Dep. 45′	Lat 45′	Dep. 30′	Lat. 30′	Dep. 15′	Lat. 15′

78 DEGREES.

Dist.	0' Lat.	0' Dep.	15' Lat.	15' Dep.	30' Lat.	30' Dep.	45' Lat.	45' Dep.
61	59.67	12.68	59.61	12.94	59.55	13.20	59.50	13.46
62	60.65	12.89	60.59	13.16	60.53	13.42	60.47	13.68
63	61.62	13.10	61.57	13.37	61.51	13.64	61.45	13.90
64	62.60	13.31	62.54	13.58	62.48	13.85	62.42	14.12
65	63.58	13.51	63.52	13.79	63.46	14.07	63.40	14.35
66	64.56	13.72	64.50	14.00	64.44	14.29	64.37	14.57
67	65.54	13.93	65.47	14.22	65.41	14.50	65.35	14.79
68	66.51	14.14	66.45	14.43	66.39	14.72	66.32	15.01
69	67.49	14.35	67.43	14.64	67.36	14.93	67.30	15.23
70	68.47	14.55	68.41	14.85	68.34	15.15	68.27	15.45
71	69.45	14.76	69.38	15.06	69.32	15.37	69.25	15.67
72	70.43	14.97	70.36	15.28	70.29	15.58	70.22	15.89
73	71.40	15.18	71.34	15.49	71.27	15.80	71.20	16.11
74	72.38	15.39	72.32	15.70	72.25	16.02	72.18	16.33
75	73.36	15.59	73.29	15.91	73.22	16.23	73.15	16.55
76	74.34	15.80	74.27	16.13	74.20	16.45	74.13	16.77
77	75.32	16.01	75.25	16.34	75.17	16.67	75.10	16.99
78	76.30	16.22	76.22	16.55	76.15	16.88	76.08	17.21
79	77.27	16.43	77.20	16.76	77.13	17.10	77.05	17.44
80	78.25	16.63	78.18	16.97	78.10	17.32	78.03	17.66
81	79.23	16.84	79.16	17.19	79.08	17.53	79.00	17.88
82	80.21	17.05	80.13	17.40	80.06	17.75	79.98	18.10
83	81.19	17.26	81.11	17.61	81.03	17.96	80.95	18.32
84	82.16	17.46	82.09	17.82	82.01	18.18	81.93	18.54
85	83.14	17.67	83.06	18.04	82.99	18.40	82.90	18.76
86	84.12	17.88	84.04	18.25	83.96	18.61	83.88	18.98
87	85.10	18.09	85.02	18.46	84.94	18.83	84.85	19.20
88	86.08	18.30	86.00	18.67	85.91	19.05	85.63	19.42
89	87.06	18.50	86.97	18.88	86.89	19.26	86.81	19.64
90	88.03	18.71	87.95	19.10	87.87	19.48	87.78	19.86
91	89.01	18.92	88.93	19.31	88.84	19.70	88.76	20.08
92	89.99	19.13	89.91	19.52	89.82	19.91	89.73	20.30
93	90.97	19.34	90.88	19.73	90.80	20.13	90.71	20.52
94	91.95	19.54	91.86	19.94	91.77	20.35	91.68	20.75
95	92.92	19.75	92.84	20.16	92.75	20.56	92.66	20.97
96	93.90	19.96	93.81	20.37	93.72	20.78	93.63	21.19
97	94.88	20.17	94.79	20.58	94.70	20.99	94.61	21.41
98	95.86	20.38	95.77	20.79	95.68	21.21	95.58	21.63
99	96.84	20.58	96.75	21.01	96.65	21.43	96.56	21.85
100	97.81	20.79	97.72	21.22	97.63	21.64	97.53	22.07
101	98.79	21.00	98.70	21.43	98.61	21.86	98.51	22.29
102	99.77	21.21	99.68	21.64	99.58	22.08	99.49	22.51
103	100.7	21.41	100.7	21.85	100.6	22.29	100.5	22.73
104	101.7	21.62	101.6	22.07	101.5	22.51	101.4	22.95
105	102.7	21.83	102.6	22.28	102.5	22.73	102.4	23.17
106	103.7	22.04	103.6	22.49	103.5	22.94	103.4	23.39
107	104.7	22.25	104.6	22.70	104.5	23.16	104.4	23.61
108	105.6	22.45	105.5	22.92	105.4	23.38	105.3	23.84
109	106.6	22.66	106.5	23.13	106.4	23.59	106.3	24.06
110	107.6	22.87	107.5	23.34	107.4	23.81	107.3	24.28
111	108.6	23.08	108.5	23.55	108.4	24.02	108.3	24.50
112	109.6	23.29	109.4	23.76	109.3	24.24	109.2	24.72
113	110.5	23.49	110.4	23.98	110.3	24.46	110.2	24.94
114	111.5	23.70	111.4	24.19	111.3	24.67	111.2	25.16
115	112.5	23.91	112.4	24.40	112.3	24.89	112.2	25.38
116	113.5	24.12	113.4	24.61	113.3	25.11	113.1	25.60
117	114.4	24.33	114.3	24.82	114.2	25.32	114.1	25.82
118	115.4	24.53	115.3	25.04	115.2	25.54	115.1	26.04
119	116.4	24.74	116.3	25.25	116.2	25.76	116.1	26.26
120	117.4	24.95	117.3	25.46	117.2	25.97	117.0	26.68
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0'		45'		30'		15'	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
1	0.97	0.23	0.97	0.23	0.97	0.23	0.97	0.24
2	1.95	0.45	1.95	0.46	1.94	0.47	1.94	0.48
3	2.92	0.67	2.92	0.69	2.92	0.70	2.91	0.71
4	3.90	0.90	3.89	0.92	3.89	0.93	3.89	0.95
5	4.87	1.12	4.87	1.15	4.86	1.17	4.86	1.19
6	5.85	1.35	5.84	1.38	5.83	1.40	5.83	1.43
7	6.82	1.57	6.81	1.60	6.81	1.63	6.80	1.66
8	7.80	1.80	7.79	1.83	7.78	1.87	7.77	1.90
9	8.77	2.02	8.76	2.06	8.75	2.10	8.74	2.14
10	9.74	2.25	9.73	2.29	9.72	2.33	9.71	2.38
11	10.72	2.47	10.71	2.52	10.70	2.57	10.68	2.61
12	11.69	2.70	11.68	2.75	11.67	2.80	11.66	2.85
13	12.67	2.92	12.65	2.98	12.64	3.03	12.63	3.09
14	13.64	3.15	13.63	3.21	13.61	3.27	13.60	3.33
15	14.62	3.37	14.60	3.44	14.59	3.50	14.57	3.57
16	15.59	3.60	15.57	3.67	15.56	3.74	15.54	3.80
17	16.56	3.82	16.55	3.90	16.53	3.97	16.51	4.04
18	17.54	4.05	17.52	4.13	17.50	4.20	17.48	4.28
19	18.51	4.27	18.49	4.35	18.48	4.44	18.46	4.52
20	19.49	4.50	19.47	4.58	19.45	4.67	19.43	4.75
21	20.46	4.72	20.44	4.81	20.42	4.90	20.40	4.99
22	21.44	4.95	21.41	5.04	21.39	5.14	21.37	5.23
23	22.41	5.17	22.39	5.27	22.36	5.37	22.34	5.47
24	23.38	5.40	23.36	5.50	23.34	5.60	23.31	5.70
25	24.36	5.62	24.33	5.73	24.31	5.84	24.28	5.94
26	25.33	5.85	25.31	5.96	25.28	6.07	25.25	6.18
27	26.31	6.07	26.28	6.19	26.25	6.30	26.23	6.42
28	27.28	6.30	27.25	6.42	27.23	6.54	27.20	6.66
29	28.26	6.52	28.23	6.65	28.20	6.77	28.17	6.89
30	29.23	6.75	29.20	6.88	29.17	7.00	29.14	7.13
31	30.21	6.97	30.17	7.11	30.14	7.24	30.11	7.37
32	31.18	7.20	31.15	7.33	31.12	7.47	31.08	7.61
33	32.15	7.42	32.12	7.56	32.09	7.70	32.05	7.84
34	33.13	7.65	33.09	7.79	33.06	7.94	33.03	8.08
35	34.10	7.87	34.07	8.02	34.03	8.17	34.00	8.32
36	35.08	8.10	35.04	8.25	35.01	8.40	34.97	8.56
37	36.05	8.32	36.02	8.48	35.98	8.64	35.94	8.79
38	37.03	8.55	36.99	8.71	36.95	8.87	36.91	9.03
39	38.00	8.77	37.96	8.94	37.92	9.10	37.88	9.27
40	38.97	9.00	38.94	9.17	38.89	9.34	38.85	9.51
41	39.95	9.22	39.91	9.40	39.87	9.57	39.83	9.75
42	40.92	9.45	40.88	9.63	40.84	9.80	40.80	9.98
43	41.90	9.67	41.86	9.86	41.81	10.04	41.77	10.22
44	42.87	9.90	42.83	10.08	42.78	10.27	42.74	10.46
45	43.85	10.12	43.80	10.31	43.76	10.51	43.71	10.70
46	44.82	10.35	44.78	10.54	44.73	10.74	44.68	10.93
47	45.80	10.57	45.75	10.77	45.70	10.97	45.65	11.17
48	46.77	10.80	46.72	11.00	46.67	11.21	46.62	11.41
49	47.74	11.02	47.70	11.23	47.65	11.44	47.60	11.65
50	48.72	11.25	48.67	11.46	48.62	11.67	48.57	11.88
51	49.69	11.47	49.64	11.69	49.59	11.91	49.54	12.12
52	50.67	11.70	50.62	11.92	50.56	12.14	50.51	12.36
53	51.64	11.92	51.59	12.15	51.54	12.37	51.48	12.60
54	52.62	12.15	52.56	12.38	52.51	12.61	52.45	12.84
55	53.59	12.37	53.54	12.61	53.48	12.84	53.42	13.07
56	54.56	12.60	54.51	12.84	54.45	13.07	54.40	13.31
57	55.54	12.82	55.48	13.06	55.43	13.31	55.37	13.55
58	56.51	13.05	56.46	13.29	56.40	13.54	56.34	13.79
59	57.49	13.27	57.43	13.52	57.37	13.77	57.31	14.02
60	58.47	13.50	58.40	13.75	58.34	14.01	58.28	14.26
Dist.	0′ Dep.	0′ Lat.	45′ Dep.	45′ Lat.	30′ Dep.	30′ Lat.	15′ Dep.	15′ Lat.

Dist.	0′ Lat.	0′ Dep.	15′ Lat	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
61	59.44	13.72	59.38	13.98	59.31	14.24	59.25	14.50
62	60.41	13.95	60.35	14.21	60.29	14.47	60.22	14.74
63	61.39	14.17	61.32	14.44	61.26	14.71	61.19	14.97
64	62.36	14.40	62.30	14.67	62.23	14.94	62.17	15.21
65	63.33	14.62	63.27	14.90	63.20	15.17	63.14	15.45
66	64.31	14.85	64.24	15.13	64.18	15.41	64.11	15.69
67	65.28	15.07	65.22	15.36	65.15	15.64	65.08	15.93
68	66.26	15.30	66.19	15.59	66.12	15.87	66.05	16.16
69	67.23	15.52	67.16	15.81	67.09	16.11	67.02	16.40
70	68.21	15.75	68.14	16.04	68.07	16.34	67.99	16.64
71	69.18	15.97	69.11	16.27	69.04	16.57	68.97	16.88
72	70.15	16.20	70.08	16.50	70.01	16.81	69.94	17.11
73	71.13	16.42	71.06	16.73	70.98	17.04	70.91	17.35
74	72.10	16.65	72.03	16.96	71.96	17.28	71.88	17.59
75	73.08	16.87	73.00	17.19	72.93	17.51	72.85	17.83
76	74.05	17.10	73.98	17.42	73.90	17.74	73.82	18.06
77	75.03	17.32	74.95	17.65	74.87	17.98	74.79	18.30
78	76.00	17.55	75.92	17.88	75.84	18.21	75.76	18.54
79	76.98	17.77	76.90	18.11	76.82	18.44	76.74	18.78
80	77.95	18.00	77.87	18.34	77.79	18.68	77.71	19.01
81	78.92	18.22	78.84	18.57	78.76	18.91	78.68	19.25
82	79.90	18.45	79.82	18.79	79.73	19.14	79.65	19.49
83	80.87	18.67	80.79	19.02	80.71	19.38	80.62	19.73
84	81.85	18.90	81.76	19.25	81.68	19.61	81.59	19.97
85	82.82	19.12	82.74	19.48	82.65	19.84	82.56	20.20
86	83.80	19.35	83.71	19.71	83.62	20.08	83.54	20.44
87	84.77	19.57	84.68	19.94	84.60	20.31	84.51	20.68
88	85.74	19.80	85.66	20.17	85.57	20.54	85.48	20.92
89	86.72	20.02	86.63	20.40	86.54	20.78	86.45	21.15
90	87.69	20.25	87.60	20.63	87.51	21.01	87.42	21.39
91	88.67	20.47	88.58	20.86	88.49	21.24	88.39	21.63
92	89.64	20.70	89.55	21.09	89.46	21.48	89.36	21.87
93	90.62	20.92	90.52	21.32	90.43	21.71	90.33	22.10
94	91.59	21.15	91.50	21.54	91.40	21.94	91.31	22.34
95	92.57	21.37	92.47	21.77	92.38	22.18	92.28	22.58
96	93.54	21.60	93.44	22.00	93.35	22.41	93.25	22.82
97	94.51	21.82	94.42	22.23	94.32	22.64	94.22	23.06
98	95.49	22.05	95.39	22.46	95.29	22.88	95.19	23.29
99	96.46	22.27	96.36	22.69	96.26	23.11	96.16	23.53
100	97.44	22.50	97.34	22.92	97.24	23.34	97.13	23.77
101	98.41	22.72	98.31	23.15	98.21	23.58	98.11	24.01
102	99.39	22.94	99.28	23.38	99.18	23.81	99.08	24.24
103	100.4	23.17	100.3	23.61	100.2	24.04	100.0	24.48
104	101.3	23.40	101.2	23.84	101.1	24.28	101.0	24.72
105	102.3	23.62	102.2	24.07	102.1	24.51	102.0	24.96
106	103.3	23.84	103.2	24.30	103.1	24.75	103.0	25.19
107	104.3	24.07	104.2	24.52	104.0	24.98	103.9	25.43
108	105.2	24.29	105.1	24.75	105.0	25.21	104.9	25.67
109	106.2	24.52	106.1	24.98	106.0	25.45	105.9	25.91
110	107.2	24.74	107.1	25.21	107.0	25.68	106.8	26.15
111	108.2	24.97	108.0	25.44	107.9	25.91	107.8	26.38
112	109.1	25.19	109.0	25.67	108.9	26.15	108.8	26.62
113	110.1	25.42	110.0	25.90	109.9	26.38	109.8	26.86
114	111.1	25.64	111.0	26.13	110.9	26.61	110.7	27.10
115	112.1	25.87	111.9	26.36	111.8	26.85	111.7	27.33
116	113.0	26.09	112.9	26.59	112.8	27.08	112.7	27.57
117	114.0	26.32	113.9	26.82	113.8	27.31	113.6	27.81
118	115.0	26.54	114.9	27.05	114.7	27.55	114.6	28.05
119	116.0	26.77	115.8	27.27	115.7	27.78	115.6	28.28
120	116.9	26.99	116.8	27.50	116.7	28.01	116.6	28.52
Dist.	Dep.	Lat	Dep	Lat.	Dep	Lat.	Dep	Lat.
	0′		45′		30′		15′	

Dist.	0' Lat.	0' Dep.	15' Lat.	15' Dep.	30' Lat.	30' Dep.	45' Lat.	45' Dep.
1	0.97	0.24	0.97	0.25	0.97	0.25	0.97	0.25
2	1.94	0.48	1.94	0.49	1.94	0.50	1.93	0.51
3	2.91	0.73	2.91	0.74	2.90	0.75	2.90	0.76
4	3.88	0.97	3.88	0.98	3.87	1.00	3.87	1.02
5	4.85	1.21	4.85	1.23	4.84	1.25	4.84	1.27
6	5.82	1.45	5.82	1.48	5.81	1.50	5.80	1.53
7	6.79	1.69	6.78	1.72	6.78	1.75	6.77	1.78
8	7.76	1.94	7.75	1.97	7.75	2.00	7.74	2.04
9	8.73	2.18	8.72	2.22	8.71	2.25	8.70	2.29
10	9.70	2.42	9.69	2.46	9.68	2.50	9.67	2.55
11	10.67	2.66	10.66	2.71	10.65	2.75	10.64	2.80
12	11.64	2.90	11.63	2.95	11.62	3.00	11.60	3.06
13	12.61	3.15	12.60	3.20	12.59	3.25	12.57	3.31
14	13.58	3.39	13.57	3.45	13.55	3.51	13.54	3.56
15	14.55	3.63	14.54	3.69	14.52	3.76	14.51	3.82
16	15.52	3.87	15.51	3.94	15.49	4.01	15.47	4.07
17	16.50	4.11	16.48	4.18	16.46	4.26	16.44	4.33
18	17.47	4.35	17.45	4.43	17.43	4.51	17.41	4.58
19	18.44	4.60	18.42	4.68	18.39	4.76	18.37	4.84
20	19.41	4.84	19.38	4.92	19.36	5.01	19.34	5.09
21	20.38	5.08	20.35	5.17	20.33	5.26	20.31	5.35
22	21.35	5.32	21.32	5.42	21.30	5.51	21.28	5.60
23	22.32	5.56	22.29	5.66	22.27	5.76	22.24	5.86
24	23.29	5.81	23.26	5.91	23.24	6.01	23.21	6.11
25	24.26	6.05	24.23	6.15	24.20	6.26	24.18	6.37
26	25.23	6.29	25.20	6.40	25.17	6.51	25.14	6.62
27	26.20	6.53	26.17	6.65	26.14	6.76	26.11	6.87
28	27.17	6.77	27.14	6.89	27.11	7.01	27.08	7.13
29	28.14	7.02	28.11	7.14	28.08	7.26	28.04	7.38
30	29.11	7.26	29.08	7.38	29.04	7.51	29.01	7.64
31	30.08	7.50	30.05	7.63	30.01	7.76	29.98	7.89
32	31.05	7.74	31.02	7.88	30.98	8.01	30.95	8.15
33	32.02	7.98	31.98	8.12	31.95	8.26	31.91	8.40
34	32.99	8.23	32.95	8.37	32.92	8.51	32.88	8.66
35	33.96	8.47	33.92	8.62	33.89	8.76	33.85	8.91
36	34.93	8.71	34.89	8.86	34.85	9.01	34.81	9.17
37	35.90	8.93	35.86	9.11	35.82	9.26	35.78	9.42
38	36.87	9.19	36.83	9.35	36.79	9.51	36.75	9.67
39	37.84	9.43	37.80	9.60	37.76	9.76	37.71	9.93
40	38.81	9.68	38.77	9.85	38.73	10.02	38.68	10.18
41	39.78	9.92	39.74	10.09	39.69	10.27	39.65	10.44
42	40.75	10.16	40.71	10.34	40.66	10.52	40.62	10.69
43	41.72	10.40	41.68	10.58	41.63	10.77	41.58	10.95
44	42.69	10.64	42.65	10.83	42.60	11.02	42.55	11.20
45	43.66	10.89	43.62	11.08	43.57	11.27	43.52	11.46
46	44.63	11.13	44.58	11.32	44.53	11.52	44.48	11.71
47	45.60	11.37	45.55	11.57	45.50	11.77	45.45	11.97
48	46.57	11.61	46.52	11.82	46.47	12.02	46.42	12.22
49	47.54	11.85	47.49	12.06	47.44	12.27	47.39	12.48
50	48.51	12.10	48.46	12.31	48.41	12.52	48.35	12.73
51	49.49	12.34	49.43	12.55	49.38	12.77	49.32	12.98
52	50.46	12.58	50.40	12.80	50.34	13.02	50.29	13.24
53	51.43	12.82	51.37	13.05	51.31	13.27	51.25	13.49
54	52.40	13.06	52.34	13.29	52.28	13.52	52.22	13.75
55	53.37	13.31	53.31	13.54	53.25	13.77	53.19	14.00
56	54.34	13.55	54.28	13.78	54.22	14.02	54.15	14.26
57	55.31	13.79	55.25	14.03	55.18	14.27	55.12	14.51
58	56.28	14.03	56.22	14.28	56.15	14.52	56.09	14.77
59	57.25	14.27	57.18	14.52	57.12	14.77	57.06	15.02
60	58.20	14.52	58.15	14.77	58.09	15.02	58.02	15.28
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0'		45'		30'		15'	

75 DEGREES.

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ De
61	59.19	14.76	59.12	15.02	59.06	15.27	58.99	15.5
62	60.16	15.00	60.09	15.26	60.03	15.52	59.96	15.7
63	61.13	15.24	61.06	15.51	60.99	15.77	60.92	16.0
64	62.10	15.48	62.03	15.75	61.96	16.02	61.89	16.2
65	63.07	15.72	63.00	16.00	62.93	16.27	62.86	16.5
66	64.04	15.97	63.97	16.25	63.90	16.53	63.83	16.8
67	65.01	16.21	64.94	16.49	64.87	16.78	64.79	17.0
68	65.98	16.45	65.91	16.74	65.83	17.03	65.76	17.3
69	66.95	16.69	66.88	16.98	66.80	17.28	66.73	17.5
70	67.92	16.93	67.85	17.23	67.77	17.53	67.69	17.8
71	68.89	17.18	68.82	17.48	68.74	17.78	68.66	18.0
72	69.86	17.42	69.78	17.72	69.71	18.03	69.63	18.3
73	70.83	17.66	70.75	17.97	70.67	18.28	70.59	18.5
74	71.80	17.90	71.72	18.22	71.64	18.53	71.56	18.8
75	72.77	18.14	72.69	18.46	72.61	18.78	72.53	19.1
76	73.74	18.39	73.66	18.71	73.58	19.03	73.50	19.3
77	74.71	18.63	74.63	18.95	74.55	19.28	74.46	19.6
78	75.68	18.87	75.60	19.20	75.52	19.53	75.43	19.8
79	76.65	19.11	76.57	19.45	76.48	19.78	76.40	20.1
80	77.62	19.35	77.54	19.69	77.45	20.03	77.36	20.3
81	78.59	19.60	78.51	19.94	78.42	20.28	78.33	20.6
82	79.56	19.84	79.48	20.18	79.39	20.53	79.30	20.8
83	80.53	20.08	80.45	20.43	80.36	20.78	80.26	21.1
84	81.50	20.32	81.42	20.68	81.32	21.03	81.23	21.3
85	82.48	20.56	82.38	20.92	82.29	21.28	82.20	21.6
86	83.45	20.81	83.35	21.17	83.26	21.53	83.17	21.9
87	84.42	21.05	84.32	21.42	84.23	21.78	84.13	22.1
88	85.39	21.29	85.29	21.66	85.20	22.03	85.10	22.4
89	86.36	21.53	86.26	21.91	86.17	22.28	86.07	22.6
90	87.33	21.77	87.23	22.15	87.13	22.53	87.03	22.9
91	88.30	22.01	88.20	22.40	88.10	22.78	88.00	23.1
92	89.27	22.26	89.17	22.65	89.07	23.04	88.97	23.4
93	90.24	22.50	90.13	22.89	90.04	23.29	89.94	23.6
94	91.21	22.74	91.11	23.14	91.01	23.54	90.90	23.9
95	92.18	22.98	92.08	23.38	91.97	23.79	91.87	24.1
96	93.15	23.22	93.05	23.63	92.94	24.04	92.84	24.4
97	94.12	23.47	94.02	23.88	93.91	24.29	93.80	24.7
98	95.09	23.71	94.98	24.12	94.88	24.54	94.77	24.9
99	96.06	23.95	95.95	24.37	95.85	24.79	95.74	25.2
100	97.03	24.19	96.92	24.62	96.81	25.04	96.70	25.4
101	98.00	24.43	97.89	24.86	97.78	25.29	97.67	25.7
102	98.97	24.68	98.86	25.11	98.75	25.54	98.64	25.9
103	99.94	24.92	99.83	25.35	99.72	25.79	99.61	26.2
104	100.9	25.16	100.8	25.60	100.7	26.04	100.6	26.4
105	101.9	25.40	101.8	25.85	101.7	26.29	101.5	26.7
106	102.9	25.64	102.7	26.09	102.6	26.54	102.5	26.9
107	103.8	25.89	103.7	26.34	103.6	26.79	103.5	27.2
108	104.8	26.13	104.7	26.58	104.6	27.04	104.4	27.5
109	105.8	26.37	105.6	26.83	105.5	27.29	105.4	27.7
110	106.7	26.61	106.6	27.08	106.5	27.54	106.4	28.0
111	107.7	26.85	107.6	27.32	107.5	27.79	107.3	28.2
112	108.7	27.10	108.6	27.57	108.4	28.04	108.3	28.5
113	109.6	27.34	109.5	27.82	109.4	28.29	109.3	28.7
114	110.6	27.58	110.5	28.06	110.4	28.54	110.2	29.0
115	111.6	27.82	111.5	28.31	111.3	28.79	111.2	29.2
116	112.6	28.06	112.4	28.55	112.3	29.04	112.2	29.5
117	113.5	28.30	113.4	28.80	113.3	29.29	113.1	29.7
118	114.5	28.55	114.4	29.05	114.2	29.54	114.1	30.0
119	115.5	28.79	115.3	29.29	115.2	29.80	115.1	30.3
120	116.4	29.03	116.3	29.54	116.2	30.05	116.0	30.4
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	L
	0′		45′		30′		15′	

75 DEGREES.

Dist.	0' Lat.	0' Dep.	15' Lat.	15' Dep.	30' Lat.	30' Dep.	45' Lat.	45' Dep.
1	0.97	0.26	0.96	0.26	0.96	0.27	0.96	0.27
2	1.93	0.52	1.93	0.53	1.93	0.53	1.92	0.54
3	2.90	0.78	2.89	0.79	2.89	0.80	2.89	0.81
4	3.86	1.04	3.86	1.05	3.85	1.07	3.85	1.09
5	4.83	1.29	4.82	1.32	4.82	1.34	4.81	1.36
6	5.80	1.55	5.79	1.58	5.78	1.60	5.77	1.63
7	6.76	1.81	6.75	1.84	6.75	1.87	6.74	1.90
8	7.73	2.07	7.72	2.10	7.71	2.14	7.70	2.17
9	8.69	2.33	8.68	2.37	8.67	2.41	8.66	2.44
10	9.66	2.59	9.65	2.63	9.64	2.67	9.62	2.71
11	10.63	2.85	10.61	2.89	10.60	2.94	10.59	2.99
12	11.59	3.11	11.58	3.16	11.56	3.21	11.55	3.26
13	12.56	3.36	12.54	3.42	12.53	3.47	12.51	3.53
14	13.52	3.62	13.51	3.68	13.49	3.74	13.47	3.80
15	14.49	3.88	14.47	3.95	14.45	4.01	14.44	4.07
16	15.45	4.14	15.44	4.21	15.42	4.28	15.40	4.34
17	16.42	4.40	16.40	4.47	16.38	4.54	16.36	4.61
18	17.39	4.66	17.37	4.73	17.35	4.81	17.32	4.89
19	18.35	4.92	18.33	5.00	18.31	5.08	18.29	5.16
20	19.32	5.18	19.30	5.26	19.27	5.34	19.25	5.43
21	20.28	5.44	20.26	5.52	20.24	5.61	20.21	5.70
22	21.25	5.69	21.23	5.79	21.20	5.88	21.17	5.97
23	22.22	5.95	22.19	6.05	22.16	6.15	22.14	6.24
24	23.18	6.21	23.15	6.31	23.13	6.41	23.10	6.51
25	24.15	6.47	24.12	6.58	24.09	6.68	24.06	6.79
26	25.11	6.73	25.08	6.84	25.05	6.95	25.02	7.06
27	26.08	6.99	26.05	7.10	26.02	7.22	25.99	7.33
28	27.05	7.25	27.01	7.36	26.98	7.48	26.95	7.60
29	28.01	7.51	27.98	7.63	27.95	7.75	27.91	7.87
30	28.98	7.76	28.94	7.89	28.91	8.02	28.87	8.14
31	29.94	8.02	29.91	8.15	29.87	8.28	29.84	8.41
32	30.91	8.28	30.87	8.42	30.84	8.55	30.80	8.69
33	31.88	8.54	31.84	8.68	31.80	8.82	31.76	8.96
34	32.84	8.80	32.80	8.94	32.76	9.09	32.72	9.23
35	33.81	9.06	33.77	9.21	33.73	9.35	33.69	9.50
36	34.77	9.32	34.73	9.47	34.69	9.62	34.65	9.77
37	35.74	9.58	35.70	9.73	35.65	9.89	35.61	10.04
38	36.71	9.84	36.66	10.00	36.62	10.16	36.57	10.31
39	37.67	10.09	37.63	10.26	37.58	10.42	37.54	10.59
40	38.64	10.35	38.59	10.52	38.55	10.69	38.50	10.86
41	39.60	10.61	39.56	10.78	39.51	10.96	39.46	11.13
42	40.57	10.87	40.52	11.05	40.47	11.22	40.42	11.40
43	41.53	11.13	41.49	11.31	41.44	11.49	41.39	11.67
44	42.50	11.39	42.45	11.57	42.40	11.76	42.35	11.94
45	43.47	11.65	43.42	11.84	43.36	12.03	43.31	12.21
46	44.43	11.91	44.38	12.10	44.33	12.29	44.27	12.49
47	45.40	12.16	45.35	12.36	45.29	12.56	45.24	12.76
48	46.36	12.42	46.31	12.63	46.25	12.83	46.20	13.03
49	47.33	12.68	47.27	12.89	47.22	13.09	47.16	13.30
50	48.30	12.94	48.24	13.15	48.18	13.36	48.12	13.57
51	49.26	13.20	49.20	13.41	49.15	13.63	49.09	13.84
52	50.23	13.46	50.17	13.68	50.11	13.90	50.05	14.11
53	51.19	13.72	51.13	13.94	51.07	14.16	51.01	14.39
54	52.16	13.98	52.10	14.20	52.04	14.43	51.97	14.66
55	53.13	14.24	53.06	14.47	53.00	14.70	52.94	14.93
56	54.09	14.49	54.03	14.73	53.96	14.97	53.90	15.20
57	55.06	14.75	54.99	14.99	54.93	15.23	54.86	15.47
58	56.02	15.01	55.96	15.26	55.89	15.50	55.82	15.74
59	57.99	15.27	56.92	15.52	56.85	15.77	56.78	16.02
60	57.96	15.53	57.89	15.78	57.82	16.03	57.75	16.29
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0'		45'		30'		15'	

Dist	0′		15′		30′		45′	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	
61	58.92	15.79	58.85	16.04	58.78	16.30	58.71	1
62	59.89	16.05	59.82	16.31	59.75	16.57	59.67	1
63	60.85	16.31	60.78	16.57	60.71	16.84	60.63	1
64	61.82	16.56	61.75	16.83	61.67	17.10	61.60	1
65	62.79	16.82	62.71	17.10	62.64	17.37	62.56	1
66	63.75	17.08	63.68	17.36	63.60	17.64	63.52	1
67	64.72	17.34	64.64	17.62	64.56	17.91	64.48	1
68	65.68	17.60	65.61	17.89	65.53	18.17	65.45	1
69	66.65	17.86	66.57	18.15	66.49	18.44	66.41	1
70	67.61	18.12	67.54	18.41	67.45	18.71	67.37	1
71	68.58	18.38	68.50	18.68	68.42	18.97	68.33	1
72	69.55	18.64	69.46	18.94	69.38	19.24	69.30	1
73	70.51	18.89	70.43	19.20	70.35	19.51	70.26	1
74	71.48	19.15	71.39	19.46	71.31	19.78	71.22	2
75	72.44	19.41	72.36	19.73	72.27	20.04	72.18	2
76	73.41	19.67	73.32	19.99	73.24	20.31	73.15	2
77	74.38	19.93	74.29	20.25	74.20	20.58	74.11	2
78	75.34	20.19	75.25	20.52	75.16	20.84	75.07	2
79	76.31	20.45	76.22	20.78	76.13	21.11	76.03	2
80	77.27	20.71	77.18	21.04	77.09	21.38	77.00	2
81	78.24	20.96	78.15	21.31	78.05	21.65	77.96	2
82	79.21	21.22	79.11	21.57	79.02	21.91	78.92	2
83	80.17	21.48	80.08	21.83	79.98	22.18	79.88	2
84	81.14	21.74	81.04	22.09	80.95	22.45	80.85	2
85	82.10	22.00	82.01	22.36	81.91	22.72	81.81	2
86	83.07	22.26	82.97	22.62	82.87	22.98	82.77	2
87	84.04	22.52	83.94	22.88	83.84	23.25	83.73	2
88	85.00	22.78	84.90	23.15	84.80	23.52	84.70	2
89	85.97	23.03	85.87	23.41	85.76	23.78	85.66	2
90	86.93	23.29	86.83	23.67	86.73	24.05	86.62	2
91	87.90	23.55	87.80	23.94	87.69	24.32	87.58	2
92	88.87	23.81	88.76	24.20	88.65	24.59	88.55	2
93	89.83	24.07	89.73	24.46	89.62	24.85	89.51	2
94	90.80	24.33	90.69	24.72	90.58	25.12	90.47	2
95	91.76	24.59	91.65	24.99	91.54	25.39	91.43	2
96	92.73	24.85	92.62	25.25	92.51	25.65	92.40	2
97	93.69	25.11	93.58	25.51	93.47	25.92	93.36	2
98	94.66	25.36	94.55	25.78	94.44	26.19	94.32	2
99	95.63	25.62	95.51	26.04	95.40	26.46	95.28	2
100	96.59	25.88	96.48	26.30	96.36	26.72	96.25	2
101	97.56	26.14	97.44	26.57	97.33	26.99	97.21	2
102	98.52	26.40	98.41	26.83	98.29	27.26	98.17	2
103	99.49	26.66	99.37	27.09	99.25	27.53	99.13	2
104	100.5	26.92	100.3	27.36	100.2	27.79	100.1	2
105	101.4	27.18	101.3	27.62	101.2	28.06	101.1	2
106	102.4	27.43	102.3	27.88	102.1	28.33	102.0	2
107	103.4	27.69	103.2	28.14	103.1	28.59	103.0	2
108	104.3	27.95	104.2	28.41	104.1	28.86	103.9	2
109	105.3	28.21	105.2	28.67	105.0	29.13	104.9	2
110	106.3	28.47	106.1	28.93	106.0	29.40	105.9	2
111	107.2	28.73	107.1	29.20	107.0	29.66	106.8	3
112	108.2	28.99	108.1	29.46	107.9	29.93	107.8	3
113	109.1	29.25	109.0	29.72	108.9	30.20	108.8	3
114	110.1	29.51	110.0	29.99	109.9	30.47	109.7	3
115	111.1	29.76	111.0	30.25	110.8	30.73	110.7	3
116	112.0	30.02	111.9	30.51	111.8	31.00	111.6	3
117	113.0	30.28	112.9	30.77	112.7	31.27	112.6	3
118	114.0	30.54	113.8	31.04	113.7	31.53	113.6	3
119	114.9	30.80	114.8	31.30	114.7	31.80	114.5	3
120	115.9	31.06	115.8	31.56	115.6	32.07	115.5	3
Dist	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
	0′		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
1	0.96	0.28	0.96	0.28	0.96	0.28	0.96	0.29
2	1.92	0.55	1.92	0.56	1.92	0.57	1.92	0.58
3	2.88	0.83	2.88	0.84	2.88	0.85	2.87	0.86
4	3.85	1.10	3.84	1.12	3.84	1.14	3.83	1.15
5	4.81	1.38	4.80	1.40	4.79	1.42	4.79	1.44
6	5.77	1.65	5.76	1.68	5.75	1.70	5.75	1.73
7	6.73	1.93	6.72	1.96	6.71	1.99	6.70	2.02
8	7.69	2.21	7.68	2.24	7.67	2.27	7.66	2.31
9	8.65	2.48	8.64	2.52	8.63	2.56	8.62	2.59
10	9.61	2.76	9.60	2.80	9.59	2.84	9.58	2.88
11	10.57	3.03	10.56	3.08	10.55	3.12	10.53	3.17
12	11.54	3.31	11.52	3.36	11.51	3.41	11.49	3.46
13	12.50	3.58	12.48	3.64	12.46	3.69	12.45	3.75
14	13.46	3.86	13.44	3.92	13.42	3.98	13.41	4.03
15	14.42	4.13	14.40	4.20	14.38	4.26	14.36	4.32
16	15.38	4.41	15.36	4.48	15.34	4.54	15.32	4.61
17	16.34	4.69	16.32	4.76	16.30	4.83	16.28	4.90
18	17.30	4.96	17.28	5.04	17.26	5.11	17.24	5.19
19	18.26	5.24	18.24	5.32	18.22	5.40	18.19	5.48
20	19.23	5.51	19.20	5.60	19.18	5.68	19.15	5.76
21	20.19	5.79	20.16	5.88	20.14	5.96	20.11	6.05
22	21.15	6.06	21.12	6.16	21.09	6.25	21.07	6.34
23	22.11	6.34	22.08	6.44	22.05	6.53	22.02	6.63
24	23.07	6.62	23.04	6.[illegible]	23.01	6.82	22.98	6.92
25	24.03	6.89	24.00	7.00	23.97	7.10	23.94	7.20
26	24.99	7.17	24.96	7.28	24.93	7.38	24.90	7.49
27	25.95	7.44	25.92	7.56	25.89	7.67	25.85	7.78
28	26.92	7.72	26.88	7.84	26.85	7.95	26.81	8.07
29	27.88	7.99	27.84	8.12	27.81	8.24	27.77	8.36
30	28.84	8.27	28.80	8.39	28.76	8.52	28.73	8.65
31	29.80	8.54	29.76	8.67	29.72	8.80	29.68	8.93
32	30.76	8.82	30.72	8.95	30.68	9.09	30.64	9.22
33	31.72	9.10	31.68	9.23	31.64	9.37	31.60	9.51
34	32.68	9.37	32.64	9.51	32.60	9.66	32.56	9.80
35	33.64	9.65	33.60	9.79	33.56	9.94	33.52	10.09
36	34.61	9.92	34.56	10.07	34.52	10.22	34.47	10.38
37	35.57	10.20	35.52	10.35	35.48	10.51	35.43	10.66
38	36.53	10.47	36.48	10.63	36.44	10.79	36.39	10.95
39	37.49	10.75	37.44	10.91	37.39	11.08	37.35	11.24
40	38.45	11.03	38.40	11.19	38.35	11.36	38.30	11.53
41	39.41	11.30	39.36	11.47	39.31	11.64	39.26	11.82
42	40.37	11.58	40.32	11.75	40.27	11.93	40.22	12.10
43	41.33	11.85	41.28	12.03	41.23	12.21	41.18	12.39
44	42.30	12.13	42.24	12.31	42.19	12.50	42.13	12.68
45	43.26	12.40	43.20	12.59	43.15	12.78	43.09	12.97
46	44.22	12.68	44.16	12.87	44.11	13.06	44.05	13.26
47	45.18	12.96	45.12	13.15	45.06	13.35	45.01	13.55
48	46.14	13.23	46.08	13.43	46.02	13.63	45.96	13.83
49	47.10	13.51	47.04	13.71	46.98	13.92	46.92	14.12
50	48.06	13.78	48.00	13.99	47.94	14.20	47.88	14.41
51	49.02	14.06	48.96	14.27	48.90	14.48	48.84	14.70
52	49.99	14.33	49.92	14.55	49.86	14.77	49.79	14.99
53	50.95	14.61	50.88	14.83	50.82	15.05	50.75	15.27
54	51.91	14.88	51.84	15.11	51.78	15.34	51.71	15.56
55	52.87	15.16	52.80	15.39	52.74	15.62	52.67	15.85
56	53.83	15.44	53.76	15.67	53.69	15.90	53.62	16.14
57	54.79	15.71	54.72	15.95	54.65	16.19	54.58	16.43
58	55.75	15.99	55.68	16.23	55.61	16.47	55.54	16.72
59	56.71	16.26	56.64	16.51	56.57	16.76	56.50	17.00
60	57.68	16.54	57.60	16.79	57.53	17.04	57.45	17.29
Dist.	0′ Dep	0′ Lat.	45′ Dep.	45′ Lat.	30′ Dep	30′ Lat.	15′ Dep.	15′ Lat.

Dist.	0′ Lat	0′ Dep	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
61	58.64	16.81	58.56	17.07	58.49	17.32	58.41	17.58
62	59.60	17.09	59.52	17.35	59.45	17.61	59.37	17.87
63	60.56	17.37	60.48	17.63	60.41	17.89	60.33	18.16
64	61.52	17.64	61.44	17.91	61.36	18.18	61.28	18.44
65	62.48	17.92	62.40	18.19	62.32	18.46	62.24	18.73
66	63.44	18.19	63.36	18.47	63.28	18.75	63.20	19.02
67	64.40	18.47	64.32	18.75	64.24	19.03	64.16	19.31
68	65.37	18.74	65.28	19.03	65.20	19.31	65.11	19.60
69	66.33	19.02	66.24	19.31	66.16	19.60	66.07	19.89
70	67.29	19.29	67.20	19.59	67.12	19.88	67.03	20.17
71	68.25	19.57	68.16	19.87	68.08	20.17	67.99	20.46
72	69.21	19.85	69.12	20.15	69.04	20.45	68.95	20.73
73	70.17	20.12	70.08	20.43	69.99	20.73	69.90	21.04
74	71.13	20.40	71.04	20.71	70.95	21.02	70.86	21.33
75	72.09	20.67	72.00	20.99	71.91	21.30	71.82	21.61
76	73.06	20.95	72.96	21.27	72.87	21.59	72.78	21.90
77	74.02	21.22	73.92	21.55	73.83	21.87	73.73	22.19
78	74.98	21.50	74.88	21.83	74.79	22.15	74.69	22.48
79	75.94	21.78	75.84	22.11	75.75	22.44	75.65	22.77
80	76.90	22.05	76.80	22.39	76.71	22.72	76.61	23.06
81	77.86	22.33	77.76	22.67	77.66	23.01	77.56	23.34
82	78.82	22.60	78.72	22.95	78.62	23.29	78.52	23.63
83	79.78	22.88	79.68	23.23	79.58	23.57	79.48	23.92
84	80.75	23.15	80.64	23.51	80.54	23.86	80.44	24.21
85	81.71	23.43	81.60	23.79	81.50	24.14	81.39	24.50
86	82.67	23.70	82.56	24.07	82.46	24.43	82.35	24.78
87	83.63	23.98	83.52	24.35	83.42	24.71	83.31	25.07
88	84.59	24.26	84.48	24.63	84.38	24.99	84.27	25.36
89	85.55	24.53	85.44	24.90	85.34	25.28	85.22	25.65
90	86.51	24.81	86.40	25.18	86.29	25.56	86.18	25.94
91	87.47	25.08	87.36	25.46	87.25	25.85	87.14	26.23
92	88.44	25.36	88.32	25.74	88.21	26.13	88.10	26.51
93	89.40	25.63	89.28	26.02	89.17	26.41	89.05	26.80
94	90.36	25.91	90.24	26.30	90.13	26.70	90.01	27.09
95	91.32	26.19	91.20	26.58	91.09	26.98	90.97	27.38
96	92.28	26.46	92.16	26.86	92.05	27.27	91.93	27.67
97	93.24	26.74	93.12	27.14	93.01	27.55	92.88	27.96
98	94.20	27.01	94.08	27.42	93.96	27.83	93.84	28.24
99	95.16	27.29	95.04	27.70	94.92	28.12	94.80	28.53
100	96.13	27.56	96.01	27.98	95.88	28.40	95.76	28.82
101	97.09	27.84	96.97	28.26	96.84	28.69	96.71	29.11
102	98.05	28.12	97.93	28.54	97.80	28.97	97.67	29.40
103	99.01	28.39	98.89	28.82	98.76	29.25	98.63	29.68
104	99.97	28.67	99.85	29.10	99.72	29.54	99.59	29.97
105	100.9	28.94	100.8	29.38	100.7	29.82	100.5	30.26
106	101.9	29.22	101.8	29.66	101.6	30.11	101.5	30.55
107	102.9	29.49	102.7	29.94	102.6	30.39	102.4	30.84
108	103.8	29.77	103.7	30.22	103.6	30.67	103.4	31.13
109	104.[illegible]	30.04	104.6	30.50	104.5	30.96	104.4	31.41
110	105.7	30.32	105.6	30.78	105.5	31.24	105.3	31.70
111	106.7	30.60	106.6	31.06	106.4	31.53	106.3	31.99
112	107.7	30.87	107.5	31.34	107.4	31.81	107.2	32.28
113	108.6	31.15	108.5	31.62	108.3	32.09	108.2	32.57
114	109.6	31.42	109.4	31.90	109.3	32.38	109.2	32.85
115	110.5	31.70	110.4	32.18	110.3	32.66	110.1	33.14
116	111.5	31.97	111.4	32.46	111.2	32.95	111.1	33.43
117	112.5	32.25	112.3	32.74	112.2	33.23	112.0	33.72
118	113.4	32.53	113.3	32.02	113.1	33.61	113.0	34.01
119	114.4	32.80	114.2	33.30	114.1	33.80	114.0	34.30
120	115.4	33.08	115.2	33.58	115.1	34.08	114.9	34.58
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat	Dep.	Lat.
	0		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
1	0.96	0.29	0.96	0.30	0.95	0.30	0.95	0.30
2	1.91	0.58	1.91	0.59	1.91	0.60	1.90	0.61
3	2.87	0.88	2.87	0.89	2.86	0.90	2.86	0.91
4	3.83	1.17	3.82	1.19	3.81	1.20	3.81	1.22
5	4.78	1.46	4.78	1.48	4.77	1.50	4.76	1.52
6	5.74	1.75	5.73	1.78	5.72	1.80	5.71	1.83
7	6.69	2.05	6.69	2.08	6.68	2.10	6.67	2.13
8	7.65	2.34	7.64	2.37	7.63	2.41	7.62	2.44
9	8.61	2.63	8.60	2.67	8.58	2.71	8.57	2.74
10	9.56	2.92	9.55	2.97	9.54	3.01	9.52	3.05
11	10.52	3.22	10.51	3.26	10.49	3.31	10.48	3.35
12	11.48	3.51	11.46	3.56	11.44	3.61	11.43	3.66
13	12.43	3.80	12.42	3.86	12.40	3.91	12.38	3.96
14	13.39	4.09	13.37	4.15	13.35	4.21	13.33	4.27
15	14.34	4.39	14.33	4.45	14.31	4.51	14.29	4.57
16	15.30	4.68	15.28	4.74	15.26	4.81	15.24	4.88
17	16.26	4.97	16.24	5.04	16.21	5.11	16.19	5.18
18	17.21	5.26	17.19	5.34	17.17	5.41	17.14	5.49
19	18.17	5.56	18.15	5.63	18.12	5.71	18.10	5.79
20	19.13	5.85	19.10	5.93	19.07	6.01	19.05	6.10
21	20.08	6.14	20.06	6.23	20.03	6.31	20.00	6.40
22	21.04	6.43	21.01	6.52	20.98	6.62	20.95	6.71
23	22.00	6.72	21.97	6.82	21.94	6.92	21.91	7.01
24	22.95	7.02	22.92	7.12	22.89	7.22	22.86	7.32
25	23.91	7.31	23.88	7.41	23.84	7.52	23.81	7.62
26	24.86	7.60	24.83	7.71	24.80	7.82	24.76	7.93
27	25.82	7.89	25.79	8.01	25.75	8.12	25.71	8.23
28	26.78	8.19	26.74	8.30	26.70	8.42	26.67	8.54
29	27.73	8.48	27.70	8.60	27.66	8.72	27.62	8.84
30	28.69	8.77	28.65	8.90	28.61	9.02	28.57	9.15
31	29.65	9.06	29.61	9.19	29.57	9.32	29.52	9.45
32	30.60	9.36	30.56	9.49	30.52	9.62	30.48	9.76
33	31.56	9.65	31.52	9.79	31.47	9.92	31.43	10.06
34	32.51	9.94	32.47	10.08	32.43	10.22	32.38	10.37
35	33.47	10.23	33.43	10.38	33.38	10.52	33.33	10.67
36	34.43	10.53	34.38	10.68	34.33	10.83	34.29	10.98
37	35.38	10.82	35.34	10.97	35.29	11.13	35.24	11.28
38	36.34	11.11	36.29	11.27	36.24	11.43	36.19	11.58
39	37.30	11.40	37.25	11.57	37.20	11.73	37.14	11.89
40	38.25	11.69	38.20	11.86	38.15	12.03	38.10	12.19
41	39.21	11.99	39.16	12.16	39.10	12.33	39.05	12.50
42	40.16	12.28	40.11	12.45	40.06	12.63	40.00	12.80
43	41.12	12.57	41.07	12.75	41.01	12.93	40.95	13.11
44	42.08	12.86	42.02	13.05	41.96	13.23	41.91	13.41
45	43.03	13.16	42.98	13.34	42.92	13.53	42.86	13.72
46	43.99	13.45	43.93	13.64	43.87	13.83	43.81	14.02
47	44.95	13.74	44.89	13.94	44.82	14.13	44.76	14.33
48	45.90	14.03	45.84	14.23	45.78	14.43	45.72	14.63
49	46.86	14.33	46.80	14.53	46.73	14.73	46.67	14.94
50	47.82	14.62	47.75	14.83	47.69	15.04	47.62	15.24
51	48.77	14.91	48.71	15.12	48.64	15.34	48.57	15.55
52	49.73	15.20	49.66	15.42	49.59	15.64	49.52	15.85
53	50.68	15.50	50.62	15.72	50.55	15.94	50.48	16.16
54	51.64	15.79	51.57	16.01	51.50	16.24	51.43	16.46
55	52.60	16.08	52.53	16.31	52.45	16.54	52.38	16.77
56	53.55	16.37	53.48	16.61	53.41	16.84	53.33	17.07
57	54.51	16.67	54.44	16.90	54.36	17.14	54.29	17.38
58	55.47	16.96	55.39	17.20	55.32	17.44	55.24	17.68
59	56.42	17.25	56.35	17.50	56.27	17.74	56.19	17.99
60	57.38	17.54	57.30	17.79	57.22	18.04	57.14	18.29
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
61	58.33	17.83	58.26	18.09	58.18	18.34	58.10	18.60
62	59.29	18.13	59.21	18.39	59.13	18.64	59.05	18.90
63	60.25	18.42	60.17	18.68	60.08	18.94	60.00	19.21
64	61.20	18.71	61.12	18.98	61.04	19.25	60.95	19.51
65	62.16	19.00	62.08	19.28	61.99	19.55	61.91	19.82
66	63.12	19.30	63.03	19.57	62.95	19.85	62.86	20.12
67	64.07	19.59	63.99	19.87	63.90	20.15	63.81	20.43
68	65.03	19.88	64.94	20.16	64.85	20.45	64.76	20.73
69	65.99	20.17	65.90	20.46	65.81	20.75	65.72	21.04
70	66.94	20.47	66.85	20.76	66.76	21.05	66.67	21.34
71	67.90	20.76	67.81	21.05	67.71	21.35	67.62	21.65
72	68.85	21.05	68.76	21.35	68.67	21.65	68.57	21.95
73	69.81	21.34	69.72	21.65	69.62	21.95	69.52	22.26
74	70.77	21.64	70.67	21.94	70.58	22.25	70.48	22.56
75	71.72	21.93	71.63	22.24	71.53	22.55	71.43	22.86
76	72.68	22.22	72.58	22.54	72.48	22.85	72.38	23.17
77	73.64	22.51	73.54	22.83	73.44	23.15	73.33	23.47
78	74.59	22.81	74.49	23.13	74.39	23.46	74.29	23.78
79	75.55	23.10	75.45	23.43	75.34	23.76	75.24	24.08
80	76.50	23.39	76.40	23.72	76.30	24.06	76.19	24.39
81	77.46	23.68	77.36	24.02	77.25	24.36	77.14	24.69
82	78.42	23.97	78.31	24.32	78.20	24.66	78.10	25.00
83	79.37	24.27	79.27	24.61	79.16	24.96	79.05	25.30
84	80.33	24.56	80.22	24.91	80.11	25.26	80.00	25.61
85	81.29	24.85	81.18	25.21	81.07	25.56	80.95	25.91
86	82.24	25.14	82.13	25.50	82.02	25.86	81.91	26.22
87	83.20	25.44	83.09	25.80	82.97	26.16	82.86	26.52
88	84.15	25.73	84.04	26.10	83.93	26.46	83.81	26.83
89	85.11	26.02	85.00	26.39	84.88	26.76	84.76	27.13
90	86.07	26.31	85.95	26.69	85.83	27.06	85.72	27.44
91	87.02	26.61	86.91	26.99	86.79	27.36	86.67	27.74
92	87.98	26.90	87.86	27.28	87.74	27.66	87.62	28.05
93	88.94	27.19	88.82	27.58	88.70	27.97	88.57	28.35
94	89.89	27.48	89.77	27.87	89.65	28.27	89.53	28.66
95	90.85	27.78	90.73	28.17	90.60	28.57	90.48	28.96
96	91.81	28.07	91.68	28.47	91.56	28.87	91.43	29.27
97	92.76	28.36	92.64	28.76	92.51	29.17	92.38	29.57
98	93.72	28.65	93.59	29.06	93.46	29.47	93.33	29.88
99	94.67	28.94	94.55	29.36	94.42	29.77	94.29	30.18
100	95.63	29.24	95.50	29.65	95.37	30.07	95.24	30.49
101	96.59	29.53	96.46	29.95	96.33	30.37	96.19	30.79
102	97.54	29.82	97.41	30.25	97.28	30.67	97.14	31.10
103	98.50	30.11	98.37	30.54	98.23	30.97	98.10	31.40
104	99.46	30.41	99.32	30.84	99.19	31.27	99.05	31.71
105	100.4	30.70	100.3	31.14	100.1	31.57	100.0	32.01
106	101.4	30.99	101.2	31.43	101.1	31.87	101.0	32.32
107	102.3	31.28	102.2	31.73	102.0	32.18	101.9	32.62
108	103.3	31.58	103.1	32.03	103.0	32.48	102.9	32.93
109	104.2	31.87	104.1	32.32	104.0	32.78	103.8	33.23
110	105.2	32.16	105.1	32.62	104.9	33.08	104.8	33.54
111	106.1	32.45	106.0	32.92	105.9	33.38	105.7	33.84
112	107.1	32.73	107.0	33.21	106.8	33.68	106.7	34.14
113	108.1	33.04	107.9	33.51	107.8	33.98	107.6	34.45
114	109.0	33.33	108.9	33.81	108.7	34.28	108.6	34.75
115	110.0	33.62	109.8	34.10	109.7	34.58	109.5	35.06
116	110.9	33.92	110.8	34.40	110.6	34.88	110.5	35.36
117	111.9	34.21	111.7	34.70	111.6	35.18	111.4	35.67
118	112.8	34.50	112.7	34.99	112.5	35.48	112.4	35.97
119	113.8	34.79	113.6	35.29	113.5	35.78	113.3	36.28
120	114.8	35.08	114.6	35.59	114.4	36.08	114.3	36.58
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0' Lat.	0' Dep.	15' Lat.	15' Dep.	30' Lat.	30' Dep.	45' Lat.	45' Dep.
1	0.95	0.31	0.93	0.31	0.95	0.32	0.95	0.32
2	1.90	0.62	1.90	0.63	1.90	0.63	1.89	0.64
3	2.85	0.93	2.85	0.94	2.85	0.95	2.84	0.96
4	3.80	1.24	3.80	1.25	3.79	1.27	3.79	1.29
5	4.76	1.55	4.75	1.57	4.74	1.59	4.73	1.61
6	5.71	1.85	5.70	1.88	5.69	1.90	5.68	1.93
7	6.66	2.15	6.65	2.19	6.64	2.22	6.63	2.25
8	7.61	2.47	7.60	2.51	7.59	2.54	7.58	2.57
9	8.56	2.78	8.55	2.82	8.53	2.86	8.52	2.89
10	9.51	3.09	9.50	3.13	9.48	3.17	9.47	3.21
11	10.46	3.40	10.45	3.44	10.43	3.49	10.42	3.54
12	11.41	3.71	11.40	3.76	11.38	3.81	11.36	3.86
13	12.36	4.02	12.35	4.07	12.33	4.13	12.31	4.18
14	13.31	4.33	13.30	4.38	13.28	4.44	13.26	4.50
15	14.27	4.64	14.25	4.70	14.22	4.76	14.20	4.82
16	15.22	4.94	15.20	5.01	15.17	5.08	15.15	5.14
17	16.17	5.25	16.14	5.32	16.12	5.39	16.10	5.46
18	17.12	5.56	17.09	5.64	17.07	5.71	17.04	5.79
19	18.07	5.87	18.04	5.95	18.02	6.03	17.99	6.11
20	19.02	6.18	18.99	6.26	18.97	6.35	18.94	6.43
21	19.97	6.49	19.94	6.58	19.91	6.66	19.89	6.75
22	20.92	6.80	20.89	6.89	20.86	6.98	20.83	7.07
23	21.87	7.11	21.84	7.20	21.81	7.30	21.78	7.39
24	22.83	7.42	22.79	7.52	22.76	7.62	22.73	7.71
25	23.78	7.73	23.74	7.83	23.71	7.93	23.67	8.04
26	24.73	8.03	24.69	8.14	24.66	8.25	24.62	8.36
27	25.68	8.34	25.64	8.46	25.60	8.57	25.57	8.68
28	26.63	8.65	26.59	8.77	26.55	8.88	26.51	9.00
29	27.58	8.96	27.54	9.08	27.50	9.20	27.46	9.32
30	28.53	9.27	28.49	9.39	28.45	9.52	28.41	9.64
31	29.48	9.58	29.44	9.71	29.40	9.84	29.35	9.96
32	30.43	9.89	30.39	10.02	30.35	10.15	30.30	10.29
33	31.38	10.20	31.34	10.33	31.29	10.47	31.25	10.61
34	32.34	10.51	32.29	10.65	32.24	10.79	32.20	10.93
35	33.29	10.82	33.24	10.96	33.19	11.11	33.14	11.25
36	34.24	11.12	34.19	11.27	34.14	11.42	34.09	11.57
37	35.19	11.43	35.14	11.59	35.09	11.74	35.04	11.89
38	36.14	11.74	36.09	11.90	36.04	12.06	35.98	12.21
39	37.09	12.05	37.04	12.21	36.98	12.37	36.93	12.54
40	38.04	12.36	37.99	12.53	37.93	12.69	37.88	12.86
41	38.99	12.67	38.94	12.84	38.88	13.01	38.82	13.18
42	39.94	12.98	39.89	13.15	39.83	13.33	39.77	13.50
43	40.90	13.29	40.84	13.47	40.78	13.64	40.72	13.82
44	41.85	13.60	41.79	13.78	41.73	13.96	41.66	14.14
45	42.80	13.91	42.74	14.09	42.67	14.28	42.61	14.46
46	43.75	14.21	43.69	14.41	43.62	14.60	43.56	14.79
47	44.70	14.52	44.64	14.72	44.57	14.91	44.51	15.11
48	45.65	14.83	45.59	15.03	45.52	15.23	45.45	15.43
49	46.60	15.14	46.54	15.35	46.47	15.55	46.40	15.75
50	47.55	15.45	47.49	15.66	47.42	15.87	47.35	16.07
51	48.50	15.76	48.43	15.97	48.36	16.18	48.29	16.39
52	49.45	16.07	49.38	16.28	49.31	16.50	49.24	16.71
53	50.41	16.38	50.33	16.60	50.26	16.82	50.19	17.04
54	51.36	16.69	51.28	16.91	51.21	17.13	51.13	17.36
55	52.31	17.00	52.23	17.22	52.16	17.45	52.08	17.68
56	53.26	17.31	53.18	17.54	53.11	17.77	53.03	18.00
57	54.21	17.61	54.13	17.85	54.05	18.09	53.98	18.32
58	55.16	17.92	55.08	18.16	55.00	18.40	54.92	18.64
59	56.11	18.23	56.03	18.48	55.95	18.72	55.87	18.96
60	57.06	18.54	56.98	18.79	56.90	19.04	56.82	19.29
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0'		45'		30'		15'	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
61	58.01	18.85	57.93	19.10	57.85	19.36	57.76	19.6
62	58.97	19.16	58.88	19.42	58.80	19.67	58.71	19.9
63	59.92	19.47	59.83	19.73	59.74	19.99	59.66	20.2
64	60.87	19.78	60.78	20.04	60.69	20.31	60.60	20.5
65	61.82	20.09	61.73	20.36	61.64	20.62	61.55	20.8
66	62.77	20.40	62.68	20.67	62.59	20.94	62.50	21.2
67	63.72	20.70	63.63	20.98	63.54	21.26	63.44	21.5
68	64.67	21.01	64.58	21.30	64.49	21.58	64.39	21.8
69	65.62	21.32	65.53	21.61	65.43	21.89	65.34	22.1
70	66.57	21.63	66.48	21.92	66.38	22.21	66.29	22.5
71	67.52	21.94	67.43	22.23	67.33	22.53	67.23	22.8
72	68.48	22.25	68.38	22.55	68.28	22.85	68.18	23.1
73	69.43	22.56	69.33	22.86	69.23	23.16	69.13	23.4
74	70.38	22.87	70.28	23.17	70.18	23.48	70.07	23.7
75	71.33	23.18	71.23	23.49	71.12	23.80	71.02	24.1
76	72.28	23.49	72.18	23.80	72.07	24.12	71.97	24.4
77	73.23	23.79	73.13	24.11	73.02	24.43	72.91	24.7
78	74.18	24.10	74.08	24.43	73.97	24.75	73.86	25.0
79	75.13	24.41	75.03	24.74	74.92	25.07	74.81	25.3
80	76.08	24.72	75.98	25.05	75.87	25.38	75.75	25.7
81	77.04	25.03	76.93	25.37	76.81	25.70	76.70	26.0
82	77.99	25.34	77.88	25.68	77.76	26.02	77.65	26.3
83	78.94	25.65	78.83	25.99	78.71	26.34	78.60	26.6
84	79.89	25.96	79.77	26.31	79.66	26.65	79.54	27.0
85	80.84	26.27	80.72	26.62	80.61	26.97	80.49	27.3
86	81.79	26.58	81.67	26.93	81.56	27.29	81.44	27.6
87	82.74	26.88	82.62	27.25	82.50	27.61	82.38	27.9
88	83.69	27.19	83.57	27.56	83.45	27.92	83.33	28.2
89	84.64	27.50	84.52	27.87	84.40	28.24	84.28	28.6
90	85.60	27.81	85.47	28.18	85.35	28.56	85.22	28.9
91	86.55	28.12	86.42	28.50	86.30	28.87	86.17	29.2
92	87.50	28.43	87.37	28.81	87.25	29.19	87.12	29.5
93	88.45	28.74	88.32	29.12	88.19	29.51	88.06	29.8
94	89.40	29.05	89.27	29.44	89.14	29.83	89.01	30.2
95	90.35	29.36	90.22	29.75	90.09	30.14	89.96	30.5
96	91.30	29.67	91.17	30.06	91.04	30.46	90.91	30.8
97	92.25	29.97	92.12	30.38	91.99	30.78	91.85	31.1
98	93.20	30.28	93.07	30.69	92.94	31.10	92.80	31.5
99	94.15	30.59	94.02	31.00	93.88	31.41	93.75	31.8
100	95.11	30.90	94.97	31.32	94.83	31.73	94.69	32.1
101	96.06	31.21	95.92	31.63	95.78	32.05	95.64	32.4
102	97.01	31.52	96.87	31.94	96.73	32.36	96.59	32.7
103	97.96	31.83	97.82	32.26	97.68	32.68	97.53	33.1
104	98.91	32.14	98.77	32.57	98.63	33.00	98.48	33.4
105	99.86	32.45	99.72	32.88	99.57	33.32	99.43	33.7
106	100.8	32.76	100.7	33.20	100.5	33.63	100.4	34.07
107	101.8	33.06	101.6	33.51	101.5	33.95	101.3	34.39
108	102.7	33.37	102.6	33.82	102.4	34.27	102.3	34.72
109	103.7	33.68	103.5	34.13	103.4	34.59	103.2	35.0
110	104.6	33.99	104.5	34.45	104.3	34.90	104.2	35.3
111	105.6	34.30	105.4	34.76	105.3	35.22	105.1	35.
112	106.5	34.61	106.4	35.07	106.2	35.54	106.1	36.
113	107.5	34.92	107.3	35.39	107.2	35.86	107.0	36.
114	108.4	35.23	108.3	35.70	108.1	36.17	108.0	36.
115	109.4	35.54	109.2	36.01	109.1	36.49	108.9	36.
116	110.3	35.85	110.2	36.33	110.0	36.81	109.8	37.
117	111.3	36.16	111.1	36.64	111.0	37.12	110.8	37
118	112.2	36.46	112.1	36.95	111.9	37.44	111.7	37.
119	113.2	36.77	113.0	37.27	112.9	37.76	112.7	38
120	114.1	37.08	114.0	37.58	113.8	38.08	113.6	38
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	L
	0′		45′		30′		15′	

Dist.	0′		15′		30′		45′	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
1	0.95	0.33	0.94	0.33	0.94	0.33	0.94	0.34
2	1.89	0.65	1.89	0.66	1.89	0.67	1.88	0.68
3	2.84	0.98	2.83	0.99	2.83	1.00	2.82	1.01
4	3.78	1.30	3.78	1.32	3.77	1.34	3.76	1.35
5	4.73	1.63	4.72	1.65	4.71	1.67	4.71	1.69
6	5.67	1.95	5.66	1.98	5.66	2.00	5.65	2.03
7	6.62	2.28	6.61	2.31	6.60	2.34	6.59	2.37
8	7.56	2.60	7.55	2.64	7.54	2.67	7.53	2.70
9	8.51	2.93	8.50	2.97	8.48	3.00	8.47	3.04
10	9.46	3.26	9.44	3.30	9.43	3.34	9.41	3.38
11	10.40	3.58	10.39	3.63	10.37	3.67	10.35	3.72
12	11.35	3.91	11.33	3.96	11.31	4.01	11.29	4.06
13	12.29	4.23	12.27	4.29	12.25	4.34	12.24	4.39
14	13.24	4.56	13.22	4.62	13.20	4.67	13.18	4.73
15	14.18	4.88	14.16	4.95	14.14	5.01	14.12	5.07
16	15.13	5.21	15.11	5.28	15.08	5.34	15.06	5.41
17	16.07	5.53	16.05	5.60	16.02	5.67	16.00	5.74
18	17.02	5.86	16.99	5.93	16.97	6.01	16.94	6.08
19	17.96	6.19	17.94	6.26	17.91	6.34	17.88	6.42
20	18.91	6.51	18.88	6.59	18.85	6.68	18.82	6.76
21	19.86	6.84	19.83	6.92	19.80	7.01	19.76	7.10
22	20.80	7.16	20.77	7.25	20.74	7.34	20.71	7.43
23	21.75	7.49	21.71	7.58	21.68	7.68	21.65	7.77
24	22.69	7.81	22.66	7.91	22.62	8.01	22.59	8.11
25	23.64	8.14	23.60	8.24	23.57	8.35	23.53	8.45
26	24.58	8.46	24.55	8.57	24.51	8.68	24.47	8.79
27	25.53	8.79	25.49	8.90	25.45	9.01	25.41	9.12
28	26.47	9.12	26.43	9.23	26.39	9.35	26.35	9.46
29	27.42	9.44	27.38	9.56	27.34	9.68	27.29	9.80
30	28.37	9.77	28.32	9.89	28.28	10.01	28.24	9.14
31	29.31	10.09	29.27	10.22	29.22	10.35	29.18	10.48
32	30.26	10.42	30.21	10.55	30.16	10.68	30.12	10.81
33	31.20	10.74	31.15	10.88	31.11	11.02	31.06	11.15
34	32.15	11.07	32.10	11.21	32.05	11.35	32.00	11.49
35	33.09	11.39	33.04	11.54	32.99	11.68	32.94	11.83
36	34.04	11.72	33.99	11.87	33.94	12.02	33.88	12.17
37	34.98	12.05	34.93	12.20	34.88	12.35	34.82	12.50
38	35.93	12.37	35.88	12.53	35.82	12.68	35.76	12.84
39	36.88	12.70	36.82	12.86	36.76	13.02	36.71	13.18
40	37.82	13.02	37.76	13.19	37.71	13.35	37.65	13.52
41	38.77	13.35	38.71	13.52	38.65	13.69	38.59	13.85
42	39.71	13.67	39.65	13.85	39.59	14.02	39.53	14.19
43	40.66	14.00	40.60	14.18	40.53	14.35	40.47	14.53
44	41.60	14.33	41.54	14.51	41.48	14.69	41.41	14.87
45	42.55	14.65	42.48	14.84	42.42	15.02	42.35	15.21
46	43.49	14.98	43.43	15.17	43.36	15.36	43.29	15.54
47	44.44	15.30	44.37	15.50	44.30	15.69	44.24	15.88
48	45.38	15.63	45.32	15.83	45.25	16.02	45.18	16.22
49	46.33	15.95	46.26	16.15	46.19	16.36	46.12	16.56
50	47.28	16.23	47.20	16.48	47.13	16.69	47.06	16.90
51	48.22	16.60	48.15	16.81	48.07	17.02	48.00	17.23
52	49.17	16.93	49.09	17.14	49.02	17.36	48.94	17.57
53	50.11	17.26	50.04	17.47	49.96	17.69	49.88	17.91
54	51.06	17.58	50.98	17.80	50.90	18.03	50.82	18.25
55	52.00	17.91	51.92	18.13	51.85	18.36	51.76	18.59
56	52.95	18.23	52.87	18.46	52.79	18.69	52.71	18.92
57	53.89	18.56	53.81	18.79	53.73	19.03	53.65	19.26
58	54.84	18.88	54.76	19.12	54.67	19.36	54.59	19.60
59	55.79	19.21	55.70	19.45	55.62	19.69	55.53	19.94
60	56.73	19.53	56.65	19.78	56.56	20.03	56.47	20.28
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′ Lat	0′ Dep	15′ Lat	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat	45′ Dep
61	57.68	19.86	57.59	20.11	57.50	20.36	57.41	20.61
62	58.62	20.19	58.53	20.44	58.44	20.70	58.35	20.95
63	59.57	20.51	59.48	20.77	59.39	21.03	59.29	21.29
64	60.51	20.84	60.42	21.10	60.33	21.36	60.24	21.63
65	61.46	21.16	61.37	21.43	61.27	21.70	61.18	21.96
66	62.40	21.49	62.31	21.76	62.21	22.03	62.12	22.30
67	63.35	21.81	63.25	22.09	63.16	22.37	63.06	22.64
68	64.30	22.14	64.20	22.42	64.10	22.70	64.00	22.98
69	65.24	22.46	65.14	22.75	65.04	23.03	64.94	23.32
70	66.19	22.79	66.09	23.08	65.98	23.37	65.88	23.65
71	67.13	23.12	67.03	23.41	66.93	23.70	66.82	23.99
72	68.08	23.44	67.97	23.74	67.87	24.03	67.76	24.33
73	69.02	23.77	68.92	24.07	68.81	24.37	68.71	24.67
74	69.97	24.09	69.86	24.40	69.76	24.70	69.65	25.01
75	70.91	24.42	70.81	24.73	70.70	25.04	70.59	25.34
76	71.86	24.74	71.75	25.06	71.64	25.37	71.53	25.68
77	72.80	25.07	72.69	25.39	72.58	25.70	72.47	26.02
78	73.75	25.39	73.64	25.72	73.53	26.04	73.41	26.36
79	74.70	25.72	74.58	26.05	74.47	26.37	74.35	26.70
80	75.64	26.05	75.53	26.38	75.41	26.70	75.29	27.03
81	76.59	26.37	76.47	26.70	76.35	27.04	76.24	27.37
82	77.53	26.70	77.42	27.03	77.30	27.37	77.18	27.71
83	78.48	27.02	78.36	27.36	78.24	27.71	78.12	28.05
84	79.42	27.35	79.30	27.69	79.18	28.04	79.06	28.39
85	80.37	27.67	80.25	28.02	80.12	28.37	80.00	28.72
86	81.31	28.00	81.19	28.35	81.07	28.71	80.94	29.06
87	82.26	28.32	82.14	28.68	82.01	29.04	81.88	29.40
88	83.21	28.65	83.08	29.01	82.95	29.37	82.82	29.74
89	84.15	28.98	84.02	29.34	83.90	29.71	83.76	30.07
90	85.10	29.30	84.97	29.67	84.84	30.04	84.71	30.41
91	86.04	29.63	85.91	30.00	85.78	30.38	85.65	30.75
92	86.99	29.95	86.86	30.33	86.72	30.71	86.59	31.09
93	87.93	30.28	87.80	30.66	87.67	31.04	87.53	31.43
94	88.88	30.60	88.74	30.99	88.61	31.38	88.47	31.76
95	89.82	30.93	89.69	31.32	89.55	31.71	89.41	32.10
96	90.77	31.25	90.63	31.65	90.49	32.05	90.35	32.44
97	91.72	31.58	91.58	31.98	91.44	32.38	91.29	32.78
98	92.66	31.91	92.52	32.31	92.38	32.71	92.24	33.12
99	93.61	32.23	93.46	32.64	93.32	33.05	93.18	33.45
100	94.55	32.56	94.41	32.97	94.26	33.38	94.12	33.79
101	95.50	32.88	95.35	33.30	95.21	33.71	95.06	34.13
102	96.44	33.21	96.30	33.63	96.15	34.05	96.00	34.47
103	97.39	33.53	97.24	33.96	97.09	34.38	96.94	34.81
104	98.33	33.86	98.19	34.29	98.03	34.72	97.88	35.14
105	99.28	34.18	99.13	34.62	98.98	35.05	98.82	35.48
106	100.2	34.51	100.1	34.95	99.92	35.38	99.76	35.82
107	101.2	34.84	101.0	35.28	100.9	35.72	100.7	36.16
108	102.1	35.16	102.0	35.61	101.8	36.05	101.6	36.49
109	103.1	35.49	102.9	35.94	102.7	36.38	102.6	36.83
110	104.0	35.81	103.8	36.27	103.7	36.72	103.5	37.17
111	105.0	36.14	104.8	36.60	104.6	37.05	104.5	37.51
112	105.9	36.46	105.7	36.93	105.6	37.39	105.4	37.85
113	106.8	36.79	106.7	37.26	106.5	37.72	106.4	38.18
114	107.8	37.11	107.6	37.58	107.5	38.05	107.3	38.52
115	108.7	37.44	108.6	37.91	108.4	38.39	108.2	38.86
116	109.7	37.77	109.5	38.24	109.3	38.72	109.2	39.20
117	110.6	38.09	110.5	38.57	110.3	39.06	110.1	39.54
118	111.6	38.42	111.4	38.90	111.2	39.39	111.1	39.87
119	112.5	38.74	112.3	39.23	112.2	39.72	112.0	40.21
120	113.5	39.07	113.3	39.56	113.1	40.06	112.9	40.55
Dist.	Dep.	Lat.	Dep	Lat.	Dep.	Lat	Dep.	Lat
	0′		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
1	0.94	0.34	0.94	0.35	0.94	0.35	0.94	0.35
2	1.88	0.68	1.88	0.69	1.87	0.70	1.87	0.71
3	2.82	1.03	2.81	1.04	2.81	1.05	2.81	1.06
4	3.76	1.37	3.75	1.38	3.75	1.40	3.74	1.42
5	4.70	1.71	4.69	1.73	4.68	1.75	4.68	1.77
6	5.64	2.05	5.63	2.08	5.62	2.10	5.61	2.13
7	6.58	2.39	6.57	2.42	6.56	2.45	6.55	2.48
8	7.52	2.74	7.51	2.77	7.49	2.80	7.48	2.83
9	8.46	3.08	8.44	3.12	8.43	3.15	8.42	3.19
10	9.40	3.42	9.38	3.46	9.37	3.50	9.35	3.54
11	10.34	3.76	10.32	3.81	10.30	3.85	10.29	3.90
12	11.28	4.10	11.26	4.15	11.24	4.20	11.22	4.25
13	12.22	4.45	12.20	4.50	12.18	4.55	12.16	4.61
14	13.16	4.79	13.13	4.85	13.11	4.90	13.09	4.96
15	14.10	5.13	14.07	5.19	14.05	5.25	14.03	5.31
16	15.04	5.47	15.01	5.54	14.99	5.60	14.96	5.67
17	15.97	5.81	15.95	5.88	15.92	5.95	15.90	6.02
18	16.91	6.16	16.89	6.23	16.86	6.30	16.83	6.38
19	17.85	6.50	17.83	6.58	17.80	6.65	17.77	6.73
20	18.79	6.84	18.76	6.92	18.73	7.00	18.70	7.09
21	19.73	7.18	19.70	7.27	19.67	7.35	19.64	7.44
22	20.67	7.52	20.64	7.61	20.61	7.70	20.57	7.79
23	21.61	7.87	21.58	7.96	21.54	8.05	21.51	8.15
24	22.55	8.21	22.52	8.31	22.48	8.40	22.44	8.50
25	23.49	8.55	23.45	8.65	23.42	8.76	23.38	8.86
26	24.43	8.89	24.39	9.00	24.35	9.11	24.31	9.21
27	25.37	9.23	25.33	9.35	25.29	9.46	25.25	9.57
28	26.31	9.58	26.27	9.69	26.23	9.81	26.18	9.92
29	27.25	9.92	27.21	10.04	27.16	10.16	27.12	10.27
30	28.19	10.26	28.15	10.38	28.10	10.51	28.05	10.63
31	29.13	10.60	29.08	10.73	29.04	10.86	28.99	10.98
32	30.07	10.94	30.02	11.08	29.97	11.21	29.92	11.34
33	31.01	11.29	30.96	11.42	30.91	11.56	30.86	11.69
34	31.95	11.63	31.90	11.77	31.85	11.91	31.79	12.05
35	32.89	11.97	32.84	12.11	32.78	12.26	32.73	12.40
36	33.83	12.31	33.77	12.46	33.72	12.61	33.66	12.75
37	34.77	12.65	34.71	12.81	34.66	12.96	34.60	13.11
38	35.71	13.00	35.65	13.15	35.59	13.31	35.54	13.46
39	36.65	13.34	36.59	13.50	36.53	13.66	36.47	13.82
40	37.59	13.68	37.53	13.84	37.47	14.01	37.41	14.17
41	38.53	14.02	38.47	14.19	38.40	14.36	38.34	14.53
42	39.47	14.36	39.40	14.54	39.34	14.71	39.28	14.88
43	40.41	14.71	40.34	14.88	40.28	15.06	40.21	15.23
44	41.35	15.05	41.28	15.23	41.21	15.41	41.15	15.59
45	42.29	15.39	42.22	15.58	42.15	15.76	42.08	15.94
46	43.23	15.73	43.16	15.92	43.09	16.11	43.02	16.30
47	44.17	16.07	44.09	16.27	44.02	16.46	43.95	16.65
48	45.11	16.42	45.03	16.61	44.96	16.81	44.89	17.01
49	46.04	16.76	45.97	16.96	45.90	17.16	45.82	17.36
50	46.98	17.10	46.91	17.31	46.83	17.51	46.76	17.71
51	47.92	17.44	47.85	17.65	47.77	17.86	47.69	18.07
52	48.86	17.79	48.79	18.00	48.71	18.21	48.63	18.42
53	49.80	18.13	49.72	18.34	49.64	18.56	49.56	18.78
54	50.74	18.47	50.66	18.69	50.58	18.91	50.50	19.13
55	51.68	18.81	51.60	19.04	51.52	19.26	51.43	19.49
56	52.62	19.15	52.54	19.38	52.45	19.61	52.37	19.84
57	53.56	19.50	53.48	19.73	53.39	19.96	53.30	20.19
58	54.50	19.84	54.42	20.07	54.33	20.31	54.24	20.55
59	55.44	20.18	55.35	20.42	55.26	20.66	55.17	20.90
60	56.38	20.52	56.29	20.77	56.20	21.01	56.11	21.26
Dist.	Dep. 0′	Lat. 0′	Dep. 45′	Lat. 45′	Dep. 30′	Lat. 30′	Dep. 15′	Lat. 15′

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
61	57.32	20.86	57.23	21.11	57.14	21.36	57.04	21.61
62	58.26	21.21	58.17	21.46	58.07	21.71	57.98	21.97
63	59.20	21.55	59.11	21.81	59.01	22.06	58.91	22.32
64	60.14	21.89	60.04	22.15	59.95	22.41	59.85	22.67
65	61.08	22.23	60.98	22.50	60.88	22.76	60.78	23.03
66	62.02	22.57	61.92	22.84	61.82	23.11	61.72	23.38
67	62.96	22.92	62.86	23.19	62.76	23.46	62.65	23.74
68	63.90	23.26	63.80	23.54	63.69	23.81	63.59	24.09
69	64.84	23.60	64.74	23.88	64.63	24.16	64.52	24.45
70	65.78	23.94	65.67	24.23	65.57	24.51	65.46	24.80
71	66.72	24.28	66.61	24.57	66.50	24.86	66.39	25.15
72	67.66	24.63	67.55	24.92	67.44	25.21	67.33	25.51
73	68.60	24.97	68.49	25.27	68.38	25.57	68.26	25.86
74	69.54	25.31	69.43	25.61	69.31	25.92	69.20	26.22
75	70.48	25.65	70.36	25.96	70.25	26.27	70.14	26.57
76	71.42	25.99	71.30	26.30	71.19	26.62	71.07	26.93
77	72.36	26.34	72.24	26.65	72.12	26.97	72.01	27.28
78	73.30	26.68	73.18	27.00	73.06	27.32	72.94	27.63
79	74.24	27.02	74.12	27.34	74.00	27.67	73.88	27.99
80	75.18	27.36	75.06	27.69	74.93	28.02	74.81	28.34
81	76.12	27.70	75.99	28.04	75.87	28.37	75.75	28.70
82	77.05	28.05	76.93	28.38	76.81	28.72	76.68	29.05
83	77.99	28.39	77.87	28.73	77.74	29.07	77.62	29.41
84	78.93	28.73	78.81	29.07	78.68	29.42	78.55	29.76
85	79.87	29.07	79.75	29.42	79.62	29.77	79.49	30.11
86	80.81	29.41	80.68	29.77	80.55	30.12	80.42	30.47
87	81.75	29.76	81.62	30.11	81.49	30.47	81.36	30.82
88	82.69	30.10	82.56	30.46	82.43	30.82	82.29	31.18
89	83.63	30.44	83.50	30.80	83.36	31.17	83.23	31.53
90	84.57	30.78	84.44	31.15	84.30	31.52	84.16	31.89
91	85.51	31.12	85.38	31.50	85.24	31.87	85.10	32.24
92	86.45	31.47	86.31	31.84	86.17	32.22	86.03	32.59
93	87.39	31.81	87.25	32.19	87.11	32.57	86.97	32.95
94	88.33	32.15	88.19	32.54	88.05	32.92	87.90	3 .30
95	89.27	32.49	89.13	32.88	88.98	33.27	88.84	33.66
96	90.21	32.83	90.07	33.23	89.92	33.62	89.77	34.01
97	91.15	33.18	91.00	33.57	90.86	33.97	90.71	34.37
98	92.09	33.52	91.94	33.92	91.79	34.32	91.64	34.72
99	93.03	33.86	92.88	34.27	92.73	34.67	92.58	35.07
100	93.97	34.20	93.82	34.61	93.67	35.02	93.51	35.43
101	94.91	34.54	94.76	34.96	94.60	35.37	94.45	35.78
102	95.85	34.89	95.70	35.30	95.54	35.72	95.38	36.14
103	96.79	35.23	96.63	35.65	96.48	36.07	96.32	36.49
104	97.73	35.57	97.57	36.00	97.41	36.42	97.25	36.85
105	98.67	35.91	98.51	36.34	98.35	36.77	98.19	37.20
106	99.61	36.25	99.45	36.69	99.29	37.12	99.12	37.55
107	100.5	36.60	100.4	37.03	100.2	37.47	100.1	37.91
108	101.5	36.94	101.3	37.38	101.2	37.82	101.0	38.26
109	102.4	37.28	102.3	37.73	102.1	38.17	101.9	38.62
110	103.4	37.62	103.2	38.07	103.0	38.52	102.9	38.97
111	104.3	37.96	104.1	38.42	104.0	38.87	103.8	39.33
112	105.2	38.31	105.1	38.77	104.9	39.22	104.7	39.68
113	106.2	38.65	106.0	39.11	105.8	39.57	105.7	40.03
114	107.1	38.99	107.0	39.46	106.8	39.92	106.6	40.39
115	108.1	39.33	107.9	39.80	107.7	40.27	107.5	40.74
116	109.0	39.67	108.8	40.15	108.7	40.62	108.5	41.10
117	109.9	40.02	109.8	40.50	109.6	40.97	109.4	41.45
118	110.9	40.36	110.7	40.84	110.5	41.32	110.3	41.81
119	111.8	40.70	111.6	41.19	111.5	41.67	111.3	42.16
120	112.8	41.04	112.6	41.53	112.4	42.02	112.2	42.52
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′ Lat	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
1	0.93	0.36	0.93	0.36	0.93	0.37	0.93	0.37
2	1.87	0.72	1.86	0.72	1.86	0.73	1.86	0.74
3	2.80	1.08	2.80	1.09	2.79	1.10	2.79	1.11
4	3.73	1.43	3.73	1.45	3.72	1.47	3.72	1.48
5	4.67	1.79	4.66	1.81	4.65	1.83	4.64	1.85
6	5.60	2.15	5.59	2.17	5.58	2.20	5.57	2.22
7	6.54	2.51	6.52	2.54	6.51	2.57	6.50	2.59
8	7.47	2.87	7.46	2.90	7.44	2.93	7.43	2.96
9	8.40	3.23	8.39	3.26	8.37	3.30	8.36	3.34
10	9.34	3.58	9.32	3.62	9.30	3.67	9.29	3.71
11	10.27	3.94	10.25	3.99	10.23	4.03	10.22	4.08
12	11.20	4.30	11.18	4.35	11.17	4.40	11.15	4.45
13	12.14	4.66	12.12	4.71	12.10	4.76	12.07	4.82
14	13.07	5.02	13.05	5.07	13.03	5.13	13.00	5.19
15	14.00	5.38	13.98	5.44	13.96	5.50	13.93	5.56
16	14.94	5.73	14.91	5.80	14.89	5.86	14.86	5.93
17	15.87	6.09	15.84	6.16	15.82	6.23	15.79	6.30
18	16.80	6.45	16.78	6.52	16.75	6.60	16.72	6.67
19	17.74	6.81	17.71	6.89	17.68	6.96	17.65	7.04
20	18.67	7.17	18.64	7.25	18.61	7.33	18.58	7.41
21	19.61	7.53	19.57	7.61	19.54	7.70	19.51	7.78
22	20.54	7.88	20.50	7.97	20.47	8.06	20.43	8.15
23	21.47	8.24	21.44	8.34	21.40	8.43	21.36	8.52
24	22.41	8.60	22.37	8.70	22.33	8.80	22.29	8.89
25	23.34	8.96	23.30	9.06	23.26	9.16	23.22	9.26
26	24.27	9.32	24.23	9.42	24.19	9.53	24.15	9.63
27	25.21	9.68	25.16	9.79	25.12	9.90	25.08	10.01
28	26.14	10.03	26.10	10.15	26.05	10.26	26.01	10.38
29	27.07	10.39	27.03	10.51	26.98	10.63	26.94	10.75
30	28.01	10.75	27.96	10.87	27.91	11.00	27.86	11.12
31	28.94	11.11	28.89	11.24	28.84	11.36	28.79	11.49
32	29.87	11.47	29.82	11.60	29.77	11.73	29.72	11.86
33	30.81	11.83	30.76	11.96	30.70	12.09	30.65	12.23
34	31.74	12.18	31.69	12.32	31.63	12.46	31.58	12.60
35	32.68	12.54	32.62	12.69	32.56	12.83	32.51	12.97
36	33.61	12.90	33.55	13.05	33.50	13.19	33.44	13.34
37	34.54	13.26	34.48	13.41	34.43	13.56	34.37	13.71
38	35.48	13.62	35.42	13.77	35.36	13.93	35.29	14.08
39	36.41	13.98	36.35	14.14	36.29	14.29	36.22	14.45
40	37.34	14.33	37.28	14.50	37.22	14.66	37.15	14.82
41	38.28	14.69	38.21	14.86	38.15	15.03	38.08	15.19
42	39.21	15.05	39.14	15.22	39.08	15.39	39.01	15.56
43	40.14	15.41	40.08	15.58	40.01	15.76	39.94	15.93
44	41.08	15.77	41.01	15.95	40.94	16.13	40.87	16.30
45	42.01	16.13	41.94	16.31	41.87	16.49	41.80	16.68
46	42.94	16.48	42.87	16.67	42.80	16.86	42.73	17.05
47	43.88	16.84	43.80	17.03	43.73	17.23	43.65	17.42
48	44.81	17.20	44.74	17.40	44.66	17.59	44.58	17.79
49	45.75	17.56	45.67	17.76	45.59	17.96	45.51	18.16
50	46.68	17.92	46.60	18.12	46.52	18.33	46.44	18.53
51	47.61	18.28	47.53	18.48	47.45	18.69	47.37	18.90
52	48.55	18.64	48.46	18.85	48.38	19.06	48.30	19.27
53	49.48	18.99	49.40	19.21	49.31	19.42	49.23	19.64
54	50.41	19.35	50.33	19.57	50.24	19.79	50.16	20.01
55	51.35	19.71	51.26	19.93	51.17	20.16	51.08	20.38
56	52.28	20.07	52.19	20.30	52.10	20.52	52.01	20.75
57	53.21	20.43	53.12	20.66	53.03	20.89	52.94	21.12
58	54.15	20.79	54.06	21.02	53.96	21.26	53.87	21.49
59	55.08	21.14	54.99	21.38	54.89	21.62	54.80	21.86
60	56.01	21.50	55.92	21.75	55.83	21.99	55.73	22.23
Dist.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′		15′		30′		45′	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
61	56.95	21.86	56.85	22.11	56.76	22.36	56.66	22.60
62	57.88	22.22	57.78	22.47	57.69	22.72	57.59	22.97
63	58.82	22.58	58.72	22.83	58.62	23.09	58.52	23.35
64	59.75	22.94	59.65	23.20	59.55	23.46	59.44	23.72
65	60.68	23.29	60.58	23.56	60.48	23.82	60.37	24.09
66	61.62	23.65	61.51	23.92	61.41	24.19	61.30	24.46
67	62.55	24.01	62.44	24.28	62.34	24.56	62.23	24.83
68	63.48	24.37	63.38	24.65	63.27	24.92	63.16	25.20
69	64.42	24.73	64.31	25.01	64.20	25.29	64.09	25.57
70	65.35	25.09	65.24	25.37	65.13	25.66	65.00	25.94
71	66.28	25.44	66.17	25.73	66.06	26.02	65.95	26.31
72	67.22	25.80	67.10	26.10	66.99	26.39	66.87	26.68
73	68.15	26.16	68.04	26.46	67.92	26.75	67.80	27.05
74	69.08	26.52	68.97	26.82	68.85	27.12	68.73	27.42
75	70.02	26.88	69.90	27.18	69.78	27.49	69.66	27.79
76	70.95	27.24	70.83	27.55	70.71	27.85	70.59	28.16
77	71.89	27.59	71.76	27.91	71.64	28.22	71.52	28.53
78	72.82	27.95	72.70	28.27	72.57	28.59	72.45	28.90
79	73.75	28.31	73.63	28.63	73.50	28.95	73.38	29.27
80	74.69	28.67	74.56	29.00	74.43	29.32	74.30	29.64
81	75.62	29.03	75.49	29.36	75.36	29.69	75.23	30.02
82	76.55	29.39	76.42	29.72	76.29	30.05	76.16	30.39
83	77.49	29.74	77.36	30.08	77.22	30.42	77.09	30.76
84	78.42	30.10	78.29	30.44	78.16	30.79	78.02	31.13
85	79.35	30.46	79.22	30.81	79.09	31.15	78.95	31.50
86	80.29	30.82	80.15	31.17	80.02	31.52	79.88	31.87
87	81.22	31.18	81.08	31.53	80.95	31.89	80.81	32.24
88	82.16	31.54	82.02	31.89	81.88	32.25	81.74	32.61
89	83.09	31.89	82.95	32.26	82.81	32.62	82.66	32.98
90	84.02	32.25	83.88	32.62	83.74	32.99	83.59	33.35
91	84.96	32.61	84.81	32.98	84.67	33.35	84.52	33.72
92	85.89	32.97	85.74	33.34	85.60	33.72	85.45	34.09
93	86.82	33.33	86.68	33.71	86.53	34.08	86.38	34.46
94	87.76	33.69	87.61	34.07	87.46	34.45	87.31	34.83
95	88.69	34.04	88.54	34.43	88.39	34.82	88.24	35.20
96	89.62	34.40	89.47	34.79	89.32	35.18	89.17	35.57
97	90.56	34.76	90.40	35.16	90.25	35.55	90.09	35.94
98	91.49	35.12	91.34	35.52	91.18	35.92	91.02	36.31
99	92.42	35.48	92.27	35.88	92.11	36.28	91.95	36.69
100	93.36	35.84	93.20	36.24	93.04	36.65	92.88	37.06
101	94.29	36.20	94.13	36.61	93.97	37.02	93.81	37.43
102	95.23	36.55	95.06	36.97	94.90	37.38	94.74	37.80
103	96.16	36.91	96.00	37.33	95.83	37.75	95.67	38.17
104	97.09	37.27	96.93	37.69	96.76	38.12	96.60	38.54
105	98.03	37.63	97.86	38.06	97.69	38.48	97.53	38.91
106	98.96	37.99	98.79	38.42	98.62	38.85	98.45	39.28
107	99.89	38.35	99.72	38.78	99.55	39.22	99.38	39.65
108	100.8	38.70	100.7	39.14	100.5	39.58	100.3	40.02
109	101.8	39.06	101.6	39.51	101.4	39.95	101.2	40.39
110	102.7	39.42	102.5	39.87	102.3	40.32	102.2	40.76
111	103.6	39.78	103.5	40.23	103.3	40.68	103.1	41.13
112	104.6	40.14	104.4	40.59	104.2	41.05	104.0	41.50
113	105.5	40.50	105.3	40.96	105.1	41.41	105.0	41.87
114	106.4	40.85	106.2	41.32	106.1	41.78	105.9	42.24
115	107.4	41.21	107.2	41.68	107.0	42.15	106.8	42.61
116	108.3	41.57	108.1	42.04	107.9	42.51	107.7	42.98
117	109.2	41.93	109.0	42.41	108.9	42.88	108.7	43.36
118	110.2	42.29	110.0	42.77	109.8	43.25	109.6	43.73
119	111.1	42.65	110.9	43.13	110.7	43.61	110.5	44.10
120	112.0	43.00	111.8	43.49	111.7	43.98	111.5	44.47
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

68 DEGREES.

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
1	0.93	0.37	0.93	0.38	0.92	0.38	0.92	0.39
2	1.85	0.75	1.85	0.76	1.85	0.77	1.84	0.77
3	2.78	1.12	2.78	1.14	2.77	1.15	2.77	1.16
4	3.71	1.50	3.70	1.51	3.70	1.53	3.69	1.55
5	4.64	1.87	4.63	1.89	4.62	1.91	4.61	1.93
6	5.56	2.25	5.55	2.27	5.54	2.30	5.53	2.32
7	6.49	2.62	6.48	2.65	6.47	2.68	6.46	2.71
8	7.42	3.00	7.40	3.03	7.39	3.06	7.38	3.09
9	8.34	3.37	8.33	3.41	8.31	3.44	8.30	3.48
10	9.27	3.75	9.26	3.79	9.24	3.83	9.22	3.87
11	10.20	4.12	10.18	4.17	10.16	4.21	10.14	4.25
12	11.13	4.50	11.11	4.54	11.09	4.59	11.07	4.64
13	12.05	4.87	12.03	4.92	12.01	4.97	11.99	5.03
14	12.98	5.24	12.96	5.30	12.93	5.36	12.91	5.41
15	13.91	5.62	13.88	5.68	13.86	5.74	13.83	5.80
16	14.83	5.99	14.81	6.06	14.78	6.12	14.76	6.19
17	15.76	6.37	15.73	6.44	15.71	6.51	15.68	6.57
18	16.69	6.74	16.66	6.82	16.63	6.89	16.60	6.96
19	17.62	7.12	17.59	7.19	17.55	7.27	17.52	7.35
20	18.54	7.49	18.51	7.57	18.48	7.65	18.44	7.73
21	19.47	7.87	19.44	7.95	19.40	8.04	19.37	8.12
22	20.40	8.24	20.36	8.33	20.33	8.42	20.29	8.51
23	21.33	8.62	21.29	8.71	21.25	8.80	21.21	8.89
24	22.25	8.99	22.21	9.09	22.17	9.18	22.13	9.28
25	23.18	9.37	23.14	9.47	23.10	9.57	23.06	9.67
26	24.11	9.74	24.06	9.84	24.02	9.95	23.98	10.05
27	25.03	10.11	24.99	10.22	24.94	10.33	24.90	10.44
28	25.96	10.49	25.92	10.60	25.87	10.72	25.82	10.83
29	26.89	10.86	26.84	10.98	26.79	11.10	26.74	11.21
30	27.82	11.24	27.77	11.36	27.72	11.48	27.67	11.60
31	28.74	11.61	28.69	11.74	28.64	11.86	28.59	11.99
32	29.67	11.99	29.62	12.12	29.56	12.25	29.51	12.37
33	30.60	12.36	30.54	12.50	30.49	12.63	30.43	12.76
34	31.52	12.74	31.47	12.87	31.41	13.01	31.35	13.15
35	32.45	13.11	32.39	13.25	32.34	13.39	32.28	13.53
36	33.38	13.49	33.32	13.63	33.26	13.78	33.20	13.92
37	34.31	13.86	34.25	14.01	34.18	14.16	34.12	14.31
38	35.23	14.24	35.17	14.39	35.11	14.54	35.04	14.69
39	36.16	14.61	36.10	14.77	36.03	14.92	35.97	15.08
40	37.09	14.98	37.02	15.15	36.96	15.31	36.89	15.47
41	38.01	15.36	37.95	15.52	37.88	15.69	37.81	15.86
42	38.94	15.73	38.87	15.90	38.80	16.07	38.73	16.24
43	39.87	16.11	39.80	16.28	39.73	16.46	39.65	16.63
44	40.80	16.48	40.72	16.66	40.65	16.84	40.58	17.02
45	41.72	16.86	41.65	17.04	41.57	17.22	41.50	17.40
46	42.65	17.23	42.57	17.42	42.50	17.60	42.42	17.79
47	43.58	17.61	43.50	17.80	43.42	17.99	43.34	18.18
48	44.50	17.98	44.43	18.18	44.35	18.37	44.27	18.56
49	45.43	18.36	45.35	18.55	45.27	18.75	45.19	18.95
50	46.36	18.73	46.28	18.93	46.19	19.13	46.11	19.34
51	47.29	19.10	47.20	19.31	47.12	19.52	47.03	19.72
52	48.21	19.48	48.13	19.69	48.04	19.90	47.95	20.11
53	49.14	19.85	49.05	20.07	48.97	20.28	48.88	20.50
54	50.07	20.23	49.98	20.45	49.89	20.66	49.80	20.88
55	51.00	20.60	50.90	20.83	50.81	21.05	50.72	21.27
56	51.92	20.98	51.83	21.20	51.74	21.43	51.64	21.66
57	52.85	21.35	52.76	21.58	52.66	21.81	52.57	22.04
58	53.78	21.73	53.68	21.96	53.59	22.20	53.49	22.43
59	54.70	22.10	54.61	22.34	54.51	22.58	54.41	22.82
60	55.63	22.48	55.53	22.72	55.43	22.96	55.33	23.20
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
61	56.56	22.85	56.46	23.10	56.36	23.34	56.25	23.59
62	57.49	23.23	57.38	23.48	57.28	23.73	57.18	23.98
63	58.41	23.60	58.31	23.85	58.20	24.11	58.10	24.36
64	59 34	23.97	59.23	24.23	59.13	24.49	59 02	24.75
65	60.27	24.35	60.16	24.61	60.05	24.87	59.94	25.14
66	61.19	24.72	61.09	24.99	60 98	25.26	60 87	25.52
67	62.12	25.10	62.01	25 37	61.90	25.64	61.79	25.91
68	63.05	25.47	62.94	25.75	62.82	26.02	62.71	26.30
69	63.98	25.85	63.86	26.13	63.75	26.41	63.63	26.68
70	64.90	26.22	64.79	26.51	64.67	26.79	64.55	27 07
71	65.83	26.60	65.71	26.88	65.60	27.17	65.48	27.46
72	66.76	26.97	66.64	27.26	66.52	27.55	66.40	27.84
73	67.68	27.35	67.56	27 64	67.44	27.94	67.32	28.23
74	68.61	27.72	68.49	28.02	68.37	28.32	68.24	28.62
75	69.54	28.10	69.42	28 40	69.29	28.70	69.17	29.00
76	70.47	28.47	70.34	28.78	70.21	29.08	70.09	29.39
77	71.39	28 84	71.27	29.16	71.14	29.47	71.01	29.78
78	72 32	29.22	72 19	29.53	72.06	29.85	71.93	30.16
79	73.25	29.59	73.12	29.91	72.99	30 23	72.85	30.55
80	74.17	29.97	74.04	30.29	73.91	30.61	73.78	30.94
81	75.10	30 34	74.97	30.67	74.83	31.00	74.70	31.32
82	76.03	30.72	75.89	31.05	75.76	31.38	75.62	31.71
83	76 96	31.09	76.82	31.43	76.68	31.76	76.54	32.10
84	77.88	31.47	77.75	31.81	77.61	32.15	77.46	32.48
85	78.81	31.84	78.67	32.19	78.53	32.53	78.39	32.87
86	79.74	32.22	79.60	32.56	79 45	32.91	79.31	33.26
87	80.66	32.59	80.52	32 94	80.38	33.29	80.23	33.64
88	81.59	32.97	81.45	33.32	81.30	33.68	81.15	34.03
89	82.52	33.34	82.37	33 70	82.23	34.06	82.08	34.42
90	83.45	33.71	83.30	34.08	83 15	34.44	83.00	34.80
91	84.37	34.09	84.22	34.46	84.07	34 82	83.92	35.19
92	85.30	34.46	85.15	34 84	85.00	35.21	84.84	35.58
93	86.23	34.84	86.08	35.21	85.92	35.59	85.76	35.96
94	87.16	35.21	87.00	35.59	86.84	35.97	86.69	36.35
95	88.08	35.59	87.93	35 97	87 77	36.35	87.61	36 74
96	89.01	35.96	88.85	36.35	88.69	36.74	88.53	37.12
97	89.94	36.34	89.78	36.73	89.62	37.12	89 45	37.51
98	90.86	36 71	90.70	37.11	90.54	37.50	90.38	37.9[illegible]
99	91.79	37.09	91.63	37.49	91.46	37 89	91.30	38.2[illegible]
100	92.72	37.46	92.55	37.86	92.39	38.27	92.22	38 [illegible]
101	93.65	37.84	93.48	38.24	93 31	38.65	93.14	39.[illegible]
102	94.57	38.21	94.41	38.62	94.24	39.03	94.06	39.[illegible]
103	95.50	38.58	95.33	39.00	95.16	39.42	94.99	39.[illegible]
104	96.43	38.96	96.26	39.38	96.08	39.80	95.91	40.[illegible]
105	97.35	39.33	97.18	39.76	97.01	40.18	96.83	40 [illegible]
106	98.28	39.71	98.11	40.14	97.93	40.56	97.75	40.[illegible]
107	99.21	40.08	99.03	40.52	98.86	40.95	98.68	41.[illegible]
108	100.1	40.46	99.96	40.89	99.78	41.33	99.60	41.[illegible]
109	101.1	40.83	100.9	41.27	100.7	41.71	100.5	42.[illegible]
110	102.0	41.21	101 8	41.65	101 6	42.10	101 4	42.[illegible]
111	102.9	41 58	102.7	42.03	102.6	42.48	102.4	42.[illegible]
112	103.8	41.96	103.7	42.41	103.5	42.86	103.3	43 [illegible]
113	104.8	42.33	104.6	42.79	104.4	43 24	104.2	43.[illegible]
114	105.7	42.71	105 5	43.17	105 3	43.63	105.1	44[illegible]
115	106.6	43.08	106.4	43.54	106.2	44.01	106.1	44.[illegible]
116	107.6	43.45	107.4	43.92	107.2	44.39	107.0	44[illegible]
117	108.5	43.83	108.3	44.30	108.1	44.77	107.9	45[illegible]
118	109 4	44.20	109.2	44.68	109.0	45.16	108.8	45.[illegible]
119	110.3	44.58	110.1	45 06	109.9	45.54	109.7	46 [illegible]
120	111.3	44.95	111.1	45.44	110.9	45.92	110.7	46.[illegible]
Dist.	Dep.	Lat.	Dep	Lat.	Dep	Lat.	Dep	L[illegible]
	0′		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
1	0.92	0.39	0.92	0.39	0.92	0.40	0.92	0.40
2	1.84	0.78	1.84	0.79	1.83	0.80	1.83	0.81
3	2.76	1.17	2.76	1.18	2.75	1.20	2.75	1.21
4	3.68	1.56	3.68	1.58	3.67	1.60	3.66	1.61
5	4.60	1.95	4.59	1.97	4.59	1.99	4.58	2.01
6	5.52	2.34	5.51	2.37	5.50	2.39	5.49	2.42
7	6.44	2.74	6.43	2.76	6.42	2.79	6.41	2.82
8	7.36	3.13	7.35	3.16	7.34	3.19	7.32	3.22
9	8.28	3.52	8.27	3.55	8.25	3.59	8.24	3.62
10	9.21	3.91	9.19	3.95	9.17	3.99	9.15	4.03
11	10.13	4.30	10.11	4.34	10.09	4.39	10.07	4.43
12	11.05	4.69	11.03	4.74	11.00	4.79	10.98	4.83
13	11.97	5.08	11.94	5.13	11.92	5.18	11.90	5.24
14	12.89	5.47	12.86	5.53	12.84	5.58	12.81	5.64
15	13.81	5.86	13.78	5.92	13.76	5.98	13.73	6.04
16	14.73	6.25	14.70	6.32	14.67	6.38	14.65	6.44
17	15.65	6.64	15.62	6.71	15.59	6.78	15.56	6.85
18	16.57	7.03	16.54	7.11	16.51	7.18	16.48	7.25
19	17.49	7.42	17.46	7.50	17.42	7.58	17.39	7.65
20	18.41	7.81	18.38	7.89	18.34	7.98	18.31	8.05
21	19.33	8.21	19.29	8.29	19.26	8.37	19.22	8.46
22	20.25	8.60	20.21	8.68	20.18	8.77	20.14	8.86
23	21.17	8.99	21.13	9.08	21.09	9.17	21.05	9.26
24	22.09	9.38	22.05	9.47	22.01	9.57	21.97	9.67
25	23.01	9.77	22.97	9.87	22.93	9.97	22.88	10.07
26	23.93	10.16	23.89	10.26	23.84	10.37	23.80	10.47
27	24.85	10.55	24.81	10.66	24.76	10.77	24.71	10.87
28	25.77	10.94	25.73	11.05	25.68	11.16	25.63	11.28
29	26.69	11.33	26.64	11.45	26.59	11.56	26.54	11.68
30	27.62	11.72	27.56	11.84	27.51	11.96	27.46	12.08
31	28.54	12.11	28.48	12.24	28.43	12.36	28.37	12.49
32	29.46	12.90	29.40	12.63	29.35	12.76	29.29	12.89
33	30.38	12.89	30.32	13.03	30.26	13.16	30.21	13.29
34	31.30	13.28	31.24	13.42	31.18	13.56	31.12	13.69
35	32.22	13.68	32.16	13.82	32.10	13.96	32.04	14.10
36	33.14	14.07	33.08	14.21	33.01	14.36	32.95	14.50
37	34.06	14.46	34.00	14.61	33.93	14.75	33.87	14.90
38	34.98	14.85	34.91	15.00	34.85	15.15	34.78	15.30
39	35.90	15.24	35.83	15.40	35.77	15.55	35.70	15.71
40	36.82	15.63	36.75	15.79	36.68	15.95	36.61	16.11
41	37.74	16.02	37.67	16.18	37.60	16.35	37.53	16.51
42	38.66	16.41	38.59	16.58	38.52	16.75	38.44	16.92
43	39.58	16.80	39.51	16.97	39.43	17.15	39.36	17.32
44	40.50	17.19	40.43	17.37	40.35	17.54	40.27	17.72
45	41.42	17.58	41.35	17.76	41.27	17.94	41.19	18.12
46	42.34	17.97	42.26	18.16	42.18	18.34	42.10	18.53
47	43.26	18.36	43.18	18.55	43.10	18.74	43.02	18.93
48	44.18	18.76	44.10	18.95	44.02	19.14	43.93	19.33
49	45.10	19.15	45.02	19.34	44.94	19.54	44.85	19.73
50	46.03	19.54	45.94	19.74	45.85	19.94	45.77	20.14
51	46.95	19.93	46.86	20.13	46.77	20.34	46.68	20.54
52	47.87	20.32	47.78	20.53	47.69	20.74	47.60	20.94
53	48.79	20.71	48.70	20.92	48.60	21.13	48.51	21.35
54	49.71	21.10	49.61	21.32	49.52	21.53	49.43	21.75
55	50.63	21.49	50.53	21.71	50.44	21.93	50.34	22.15
56	51.55	21.88	51.45	22.11	51.36	22.33	51.26	22.55
57	52.47	22.27	52.37	22.50	52.27	22.73	52.17	22.96
58	53.39	22.66	53.29	22.90	53.19	23.13	53.09	23.36
59	54.31	23.05	54.21	23.29	54.11	23.53	54.00	23.76
60	55.23	23.44	55.13	23.68	55.02	23.92	54.92	24.16
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
61	56.15	23.83	56.05	24.08	55.94	24.32	55.83	24.57
62	57.07	24.23	56.97	24.47	56.86	24.72	56.75	24.97
63	57.99	24.62	57.88	24.87	57.77	25.12	57.66	25.37
64	58.91	25.01	58.80	25.26	58.69	25.52	58.58	25.78
65	59.83	25.40	59.72	25.66	59.61	25.92	59.50	26.18
66	60.75	25.79	60.64	26.05	60.53	26.32	60.41	26.58
67	61.67	26.18	61.56	26.45	61.44	26.72	61.33	26.98
68	62.59	26.57	62.48	26.84	62.36	27.11	62.24	27.39
69	63.51	26.96	63.40	27.24	63.28	27.51	63.16	27.79
70	64.44	27.35	64.32	27.63	64.19	27.91	64.07	28.19
71	65.36	27.74	65.23	28.03	65.11	28.31	64.99	28.60
72	66.28	28.13	66.15	28.42	66.03	28.71	65.90	29.00
73	67.20	28.52	67.07	28.82	66.95	29.11	66.82	29.40
74	68.12	28.91	67.99	29.21	67.86	29.51	67.73	29.80
75	69.04	29.30	68.91	29.61	68.78	29.91	68.65	30.21
76	69.96	29.70	69.83	30.00	69.70	30.30	69.56	30.61
77	70.88	30.09	70.75	30.40	70.61	30.70	70.48	31.01
78	71.80	30.48	71.67	30.79	71.53	31.10	71.39	31.41
79	72.72	30.87	72.58	31.18	72.45	31.50	72.31	31.82
80	73.64	31.26	73.50	31.58	73.36	31.90	73.22	32.22
81	74.56	31.65	74.42	31.97	74.28	32.30	74.14	32.62
82	75.48	32.04	75.34	32.37	75.20	32.70	75.06	33.03
83	76.40	32.43	76.26	32.76	76.12	33.10	75.97	33.43
84	77.32	32.82	77.18	33.16	77.03	33.49	76.89	33.83
85	78.24	33.21	78.10	33.55	77.95	33.89	77.80	34.23
86	79.16	33.60	79.02	33.95	78.87	34.29	78.72	34.64
87	80.08	33.99	79.93	34.34	79.78	34.69	79.63	35.04
88	81.00	34.38	80.85	34.74	80.70	35.09	80.55	35.44
89	81.92	34.78	81.77	35.13	81.62	35.49	81.46	35.84
90	82.85	35.17	82.69	35.53	82.54	35.89	82.38	36.25
91	83.77	35.56	83.61	35.92	83.45	36.29	83.29	36.65
92	84.69	35.95	84.53	36.32	84.37	36.68	84.21	37.05
93	85.61	36.34	85.45	36.71	85.29	37.08	85.12	37.46
94	86.53	36.73	86.37	37.11	86.20	37.48	86.04	37.86
95	87.45	37.12	87.29	37.50	87.12	37.88	86.95	38.26
96	88.37	37.51	88.20	37.90	88.04	38.28	87.87	38.66
97	89.29	37.90	89.12	38.29	88.95	38.68	88.79	39.07
98	90.21	38.29	90.04	38.68	89.87	39.08	89.70	39.47
99	91.13	38.68	90.96	39.08	90.79	39.48	90.62	39.87
100	92.05	39.07	91.88	39.47	91.71	39.87	91.53	40.27
101	92.97	39.46	92.80	39.87	92.62	40.27	92.45	40.68
102	93.89	39.85	93.72	40.26	93.54	40.67	93.36	41.08
103	94.81	40.25	94.64	40.66	94.46	41.07	94.28	41.48
104	95.73	40.64	95.55	41.05	95.37	41.47	95.19	41.89
105	96.65	41.03	96.47	41.45	96.29	41.87	96.11	42.29
106	97.57	41.42	97.39	41.84	97.21	42.27	97.02	42.69
107	98.49	41.81	98.31	42.24	98.13	42.67	97.94	43.09
108	99.41	42.20	99.23	42.63	99.04	43.07	98.85	43.50
109	100.3	42.59	100.1	43.03	99.96	43.46	99.77	43.90
110	101.3	42.98	101.1	43.42	100.9	43.86	100.7	44.30
111	102.2	43.37	102.0	43.82	101.8	44.26	101.6	44.70
112	103.1	43.76	102.9	44.21	102.7	44.66	102.5	45.11
113	104.0	44.15	103.8	44.61	103.6	45.06	103.4	45.51
114	104.9	44.54	104.7	45.00	104.5	45.46	104.3	45.91
115	105.9	44.93	105.7	45.40	105.5	45.86	105.3	46.32
116	106.8	45.32	106.6	45.79	106.4	46.25	106.2	46.72
117	107.7	45.72	107.5	46.19	107.3	46.65	107.1	47.12
118	108.6	46.11	108.4	46.58	108.2	47.05	108.0	47.52
119	109.5	46.50	109.3	46.97	109.1	47.45	108.9	47.93
120	110.5	46.89	110.3	47.37	110.0	47.85	109.8	48.33
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′		15′		30′		45′	
	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
1	0.91	0.41	0.91	0.41	0.91	0.41	0.91	0.42
2	1.83	0.81	1.82	0.82	1.82	0.83	1.82	0.84
3	2.74	1.22	2.74	1.23	2.73	1.24	2.72	1.26
4	3.65	1.63	3.65	1.64	3.64	1.66	3.63	1.67
5	4.57	2.03	4.56	2.05	4.55	2.07	4.54	2.09
6	5.48	2.44	5.47	2.46	5.46	2.49	5.45	2.51
7	6.39	2.85	6.38	2.88	6.37	2.90	6.36	2.93
8	7.31	3.25	7.29	3.29	7.28	3.32	7.27	3.35
9	8.22	3.66	8.21	3.70	8.19	3.73	8.17	3.77
10	9.14	4.07	9.12	4.11	9.10	4.15	9.08	4.19
11	10.05	4.47	10.03	4.52	10.01	4.56	9.99	4.61
12	10.96	4.88	10.94	4.93	10.92	4.98	10.90	5.02
13	11.88	5.29	11.85	5.34	11.83	5.39	11.81	5.44
14	12.79	5.69	12.76	5.75	12.74	5.81	12.71	5.86
15	13.70	6.10	13.68	6.16	13.65	6.22	13.62	6.28
16	14.62	6.51	14.59	6.57	14.56	6.64	14.53	6.70
17	15.53	6.91	15.50	6.98	15.47	7.05	15.44	7.12
18	16.44	7.32	16.41	7.39	16.38	7.46	16.35	7.54
19	17.36	7.73	17.32	7.80	17.29	7.88	17.25	7.95
20	18.27	8.13	18.24	8.21	18.20	8.29	18.16	8.37
21	19.18	8.54	19.15	8.63	19.11	8.71	19.07	8.79
22	20.10	8.95	20.06	9.04	20.02	9.12	19.98	9.21
23	21.01	9.35	20.97	9.45	20.93	9.54	20.89	9.63
24	21.93	9.76	21.88	9.86	21.84	9.95	21.80	10.05
25	22.84	10.17	22.79	10.27	22.75	10.37	22.70	10.47
26	23.75	10.58	23.71	10.68	23.66	10.78	23.61	10.89
27	24.67	10.98	24.62	11.09	24.57	11.20	24.52	11.30
28	25.58	11.39	25.53	11.50	25.48	11.61	25.43	11.72
29	26.49	11.80	26.44	11.91	26.39	12.03	26.34	12.14
30	27.41	12.20	27.35	12.32	27.30	12.44	27.24	12.56
31	28.32	12.61	28.26	12.73	28.21	12.86	28.15	12.98
32	29.23	13.02	29.18	13.14	29.12	13.27	29.06	13.40
33	30.15	13.42	30.09	13.55	30.03	13.68	29.97	13.82
34	31.06	13.83	31.00	13.96	30.94	14.10	30.88	14.23
35	31.97	14.24	31.91	14.38	31.85	14.51	31.78	14.65
36	32.89	14.64	32.82	14.79	32.76	14.93	32.69	15.07
37	33.80	15.05	33.74	15.20	33.67	15.34	33.60	15.49
38	34.71	15.46	34.65	15.61	34.58	15.76	34.51	15.91
39	35.63	15.86	35.56	16.02	35.49	16.17	35.42	16.33
40	36.54	16.27	36.47	16.43	36.40	16.59	36.33	16.75
41	37.46	16.68	37.38	16.84	37.31	17.00	37.23	17.17
42	38.37	17.08	38.29	17.25	38.22	17.42	38.14	17.58
43	39.28	17.49	39.21	17.66	39.13	17.83	39.05	18.00
44	40.20	17.90	40.12	18.07	40.04	18.25	39.96	18.42
45	41.11	18.30	41.03	18.48	40.95	18.66	40.87	18.84
46	42.02	18.71	41.94	18.89	41.86	19.08	41.77	19.26
47	42.94	19.12	42.85	19.30	42.77	19.49	42.68	19.68
48	43.85	19.52	43.76	19.71	43.68	19.91	43.59	20.10
49	44.76	19.93	44.68	20.13	44.59	20.32	44.50	20.51
50	45.68	20.34	45.59	20.54	45.50	20.73	45.41	20.93
51	46.59	20.74	46.50	20.95	46.41	21.15	46.32	21.35
52	47.50	21.15	47.41	21.36	47.32	21.56	47.22	21.77
53	48.42	21.56	48.32	21.77	48.23	21.98	48.13	22.19
54	49.33	21.96	49.24	22.18	49.14	22.39	49.04	22.61
55	50.25	22.37	50.15	22.59	50.05	22.81	49.95	23.03
56	51.16	22.78	51.06	23.00	50.96	23.22	50.86	23.44
57	52.07	23.18	51.97	23.41	51.87	23.64	51.76	23.86
58	52.99	23.59	52.88	23.82	52.78	24.05	52.67	24.28
59	53.90	24.00	53.79	24.23	53.69	24.47	53.58	24.70
60	54.81	24.40	54.71	24.64	54.60	24.88	54.49	25.12
Dist.	Dep	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
61	55.73	24.81	55.62	25.05	55.51	25.30	55.40	25.54
62	56.64	25.22	56.53	25.46	56.42	25.71	56.30	25.96
63	57.55	25.62	57.44	25.88	57.33	26.13	57.21	26.38
64	58.47	26.03	58.35	26.29	58.24	26.54	58.12	26.79
65	59.38	26.44	59.26	26.70	59.15	26.96	59.03	27.21
66	60.29	26.84	60.18	27.11	60.06	27.37	59.94	27.63
67	61.21	27.25	61.09	27.52	60.97	27.78	60.85	28.05
68	62.12	27.66	62.00	27.93	61.88	28.20	61.75	28.47
69	63.03	28.06	62.91	28.34	62.79	28.61	62.66	28.89
70	63.95	28.47	63.82	28.75	63.70	29.03	63.57	29.31
71	64.86	28.88	64.74	29.16	64.61	29.44	64.48	29.72
72	65.78	29.29	65.65	29.57	65.52	29.86	65.39	30.14
73	66.69	29.69	66.56	29.98	66.43	30.27	66.29	30.56
74	67.60	30.10	67.47	30.39	67.34	30.69	67.20	30.98
75	68.52	30.51	68.38	30.80	68.25	31.10	68.11	31.40
76	69.43	30.91	69.29	31.21	69.16	31.52	69.02	31.82
77	70.34	31.32	70.21	31.63	70.07	31.93	69.93	32.24
78	71.26	31.73	71.12	32.04	70.98	32.35	70.84	32.66
79	72.17	32.13	72.03	32.45	71.89	32.76	71.74	33.07
80	73.08	32.54	72.94	32.86	72.80	33.18	72.65	33.49
81	74.00	32.95	73.85	33.27	73.71	33.59	73.56	33.91
82	74.91	33.35	74.76	33.68	74.62	34.00	74.47	34.33
83	75.82	33.76	75.68	34.09	75.53	34.42	75.38	34.75
84	76.74	34.17	76.59	34.50	76.44	34.83	76.28	35.17
85	77.65	34.57	77.50	34.91	77.35	35.25	77.19	35.59
86	78.56	34.98	78.41	35.32	78.26	35.66	78.10	36.00
87	79.48	35.39	79.32	35.73	79.17	36.08	79.01	36.42
88	80.39	35.79	80.24	36.14	80.08	36.49	79.92	36.84
89	81.31	36.20	81.15	36.55	80.99	36.91	80.82	37.26
90	82.22	36.61	82.06	36.96	81.90	37.32	81.73	37.68
91	83.13	37.01	82.97	37.38	82.81	37.74	82.64	38.10
92	84.05	37.42	83.88	37.79	83.72	38.15	83.55	38.52
93	84.96	37.83	84.79	38.20	84.63	38.57	84.46	38.94
94	85.87	38.23	85.71	38.61	85.54	38.98	85.37	39.35
95	86.79	38.64	86.62	39.02	86.45	39.40	86.27	39.77
96	87.70	39.05	87.53	39.43	87.36	39.81	87.18	40.19
97	88.61	39.45	88.44	39.84	88.27	40.23	88.09	40.61
98	89.53	39.86	89.35	40.25	89.18	40.64	89.00	41.03
99	90.44	40.27	90.26	40.66	90.09	41.05	89.91	41.45
100	91.35	40.67	91.18	41.07	91.00	41.47	90.81	41.87
101	92.27	41.08	92.09	41.48	91.91	41.88	91.72	42.28
102	93.18	41.49	93.00	41.89	92.82	42.30	92.63	42.70
103	94.10	41.89	93.91	42.30	93.73	42.71	93.54	43.12
104	95.01	42.30	94.82	42.71	94.64	43.13	94.45	43.54
105	95.92	42.71	95.74	43.13	95.55	43.54	95.35	43.96
106	96.84	43.11	96.65	43.54	96.46	43.96	96.26	44.38
107	97.75	43.52	97.56	43.95	97.37	44.37	97.17	44.80
108	98.66	43.93	98.47	44.36	98.28	44.79	98.08	45.22
109	99.58	44.33	99.38	44.77	99.19	45.20	98.99	45.63
110	100.5	44.74	100.3	45.18	100.1	45.62	99.90	46.05
111	101.4	45.15	101.2	45.59	101.0	46.03	100.8	46.47
112	102.3	45.55	102.1	46.00	101.9	46.45	101.7	46.89
113	103.2	45.96	103.0	46.41	102.8	46.86	102.6	47.31
114	104.1	46.37	103.9	46.82	103.7	47.28	103.5	47.73
115	105.1	46.77	104.9	47.23	104.6	47.69	104.4	48.15
116	106.0	47.18	105.8	47.64	105.6	48.10	105.3	48.56
117	106.9	47.59	106.7	48.05	106.5	48.52	106.3	48.98
118	107.8	48.00	107.6	48.46	107.4	48.93	107.2	49.40
119	108.7	48.40	108.5	48.88	108.3	49.35	108.1	49.82
120	109.6	48.81	109.4	49.29	109.2	49.76	109.0	50.24
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′		15′		30′		45′	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
1	0.91	0.42	0.90	0.43	0.90	0.43	0.90	0.43
2	1.81	0.85	1.81	0.85	1.81	0.86	1.80	0.87
3	2.72	1.27	2.71	1.28	2.71	1.29	2.70	1.30
4	3.63	1.69	3.62	1.71	3.61	1.72	3.60	1.74
5	4.53	2.11	4.52	2.13	4.51	2.15	4.50	2.17
6	5.44	2.54	5.43	2.56	5.42	2.58	5.40	2.61
7	6.34	2.96	6.33	2.99	6.32	3.01	6.30	3.04
8	7.25	3.38	7.24	3.41	7.22	3.44	7.21	3.48
9	8.16	3.80	8.14	3.84	8.12	3.87	8.11	3.91
10	9.06	4.23	9.04	4.27	9.03	4.31	9.01	4.34
11	9.97	4.65	9.95	4.69	9.93	4.74	9.91	4.78
12	10.88	5.07	10.85	5.12	10.83	5.17	10.81	5.21
13	11.78	5.49	11.76	5.55	11.73	5.60	11.71	5.65
14	12.69	5.92	12.66	5.97	12.64	6.03	12.61	6.08
15	13.59	6.34	13.57	6.40	13.54	6.46	13.51	6.52
16	14.50	6.76	14.47	6.83	14.44	6.89	14.41	6.95
17	15.41	7.18	15.38	7.25	15.34	7.32	15.31	7.39
18	16.31	7.61	16.28	7.68	16.25	7.75	16.21	7.82
19	17.22	8.03	17.18	8.10	17.15	8.18	17.11	8.25
20	18.13	8.45	18.09	8.53	18.05	8.61	18.01	8.69
21	19.03	8.88	18.99	8.96	18.95	9.04	18.91	9.12
22	19.94	9.30	19.90	9.38	19.86	9.47	19.82	9.56
23	20.85	9.72	20.80	9.81	20.76	9.90	20.72	9.99
24	21.75	10.14	21.71	10.24	21.66	10.33	21.62	10.43
25	22.66	10.57	22.61	10.66	22.56	10.76	22.52	10.86
26	23.56	10.99	23.52	11.09	23.47	11.19	23.42	11.30
27	24.47	11.41	24.42	11.52	24.37	11.62	24.32	11.73
28	25.38	11.83	25.32	11.94	25.27	12.05	25.22	12.16
29	26.28	12.26	26.23	12.37	26.18	12.48	26.12	12.60
30	27.19	12.68	27.13	12.80	27.08	12.92	27.02	13.03
31	28.10	13.10	28.04	13.22	27.98	13.35	27.92	13.47
32	29.00	13.52	28.94	13.65	28.88	13.78	28.82	13.90
33	29.91	13.95	29.85	14.08	29.79	14.21	29.72	14.34
34	30.81	14.37	30.75	14.50	30.69	14.64	30.62	14.77
35	31.72	14.79	31.66	14.93	31.59	15.07	31.52	15.21
36	32.63	15.21	32.56	15.36	32.49	15.50	32.43	15.64
37	33.53	15.64	33.46	15.78	33.40	15.93	33.33	16.07
38	34.44	16.06	34.37	16.21	34.30	16.36	34.23	16.51
39	35.35	16.48	35.27	16.64	35.20	16.79	35.13	16.94
40	36.25	16.90	36.18	17.06	36.10	17.22	36.03	17.38
41	37.16	17.33	37.08	17.49	37.01	17.65	36.93	17.81
42	38.06	17.75	37.99	17.92	37.91	18.08	37.83	18.25
43	38.97	18.17	38.89	18.34	38.81	18.51	38.73	18.68
44	39.88	18.60	39.80	18.77	39.71	18.94	39.63	19.12
45	40.78	19.02	40.70	19.20	40.62	19.37	40.53	19.55
46	41.69	19.44	41.60	19.62	41.52	19.80	41.43	19.98
47	42.60	19.86	42.51	20.05	42.42	20.23	42.33	20.42
48	43.50	20.29	43.41	20.48	43.32	20.66	43.23	20.85
49	44.41	20.71	44.32	20.90	44.23	21.10	44.13	21.29
50	45.32	21.13	45.22	21.33	45.13	21.53	45.03	21.72
51	46.22	21.55	46.13	21.76	46.03	21.96	45.94	22.16
52	47.13	21.98	47.03	22.18	46.93	22.39	46.84	22.59
53	48.03	22.40	47.94	22.61	47.84	22.82	47.74	23.03
54	48.94	22.82	48.84	23.03	48.74	23.25	48.64	23.46
55	49.85	23.24	49.74	23.46	49.64	23.68	49.54	23.89
56	50.75	23.67	50.65	23.89	50.54	24.11	50.44	24.33
57	51.66	24.09	51.55	24.31	51.45	24.54	51.34	24.76
58	52.57	24.51	52.46	24.74	52.35	24.97	52.24	25.20
59	53.47	24.93	53.36	25.17	53.25	25.40	53.14	25.63
60	54.38	25.36	54.27	25.59	54.16	25.83	54.04	26.07
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
61	55.28	25.78	55.17	26.02	55.06	26.26	54.94	26.50
62	56.19	26.20	56.08	26.45	55.96	26.69	55.84	26.94
63	57.10	26.63	56.98	26.87	56.86	27.12	56.74	27.37
64	58.00	27.05	57.89	27.30	57.77	27.55	57.64	27.80
65	58.91	27.47	58.79	27.73	58.67	27.98	58.55	28.21
66	59.82	27.89	59.69	28.15	59.57	28.41	59.45	28.67
67	60.72	28.32	60.60	28.58	60.47	28.84	60.35	29.11
68	61.63	28.74	61.50	29.01	61.38	29.27	61.25	29.54
69	62.54	29.16	62.41	29.43	62.28	29.71	62.15	29.98
70	63.44	29.58	63.31	29.86	63.18	30.14	63.05	30.41
71	64.35	30.01	64.22	30.29	64.08	30.57	63.95	30.85
72	65.25	30.43	65.12	30.71	64.99	31.00	64.85	31.28
73	66.16	30.85	66.03	31.14	65.89	31.43	65.75	31.71
74	67.07	31.27	66.93	31.57	66.79	31.86	66.65	32.15
75	67.97	31.70	67.83	31.99	67.69	32.29	67.55	32.58
76	68.88	32.12	68.74	32.42	68.60	32.72	68.45	33.02
77	69.79	32.54	69.64	32.85	69.50	33.15	69.35	33.45
78	70.69	32.96	70.55	33.27	70.40	33.58	70.25	33.89
79	71.60	33.39	71.45	33.70	71.30	34.01	71.16	34.32
80	72.50	33.81	72.36	34.13	72.21	34.44	72.06	34.76
81	73.41	34.23	73.26	34.55	73.11	34.87	72.96	35.19
82	74.32	34.65	74.17	34.98	74.01	35.30	73.86	35.62
83	75.22	35.08	75.07	35.41	74.91	35.73	74.76	36.06
84	76.13	35.50	75.97	35.83	75.82	36.16	75.66	36.49
85	77.04	35.92	76.88	36.26	76.72	36.59	76.56	36.93
86	77.94	36.35	77.78	36.68	77.62	37.02	77.46	37.36
87	78.85	36.77	78.69	37.11	78.52	37.45	78.36	37.80
88	79.76	37.19	79.59	37.54	79.43	37.89	79.26	38.23
89	80.66	37.61	80.50	37.96	80.33	38.32	80.16	38.67
90	81.57	38.04	81.40	38.39	81.23	38.75	81.06	39.10
91	82.47	38.46	82.31	38.82	82.14	39.18	81.96	39.53
92	83.38	38.88	83.21	39.24	83.04	39.61	82.86	39.97
93	84.29	39.30	84.11	39.67	83.94	40.04	83.76	40.40
94	85.19	39.73	85.02	40.10	84.84	40.47	84.67	40.84
95	86.10	40.15	85.92	40.52	85.75	40.90	85.57	41.27
96	87.01	40.57	86.83	40.95	86.65	41.33	86.47	41.71
97	87.91	40.99	87.73	41.38	87.55	41.76	87.37	42.14
98	88.82	41.42	88.64	41.80	88.45	42.19	88.27	42.58
99	89.72	41.84	89.54	42.23	89.36	42.62	89.17	43.01
100	90.63	42.26	90.45	42.66	90.26	43.05	90.07	43.44
101	91.54	42.68	91.35	43.08	91.16	43.48	90.97	43.88
102	92.44	43.11	92.25	43.51	92.06	43.91	91.87	44.31
103	93.35	43.53	93.16	43.94	92.97	44.34	92.77	44.75
104	94.26	43.95	94.06	44.36	93.87	44.77	93.67	45.18
105	95.16	44.38	94.97	44.79	94.77	45.20	94.57	45.62
106	96.07	44.80	95.87	45.22	95.67	45.63	95.47	46.05
107	96.97	45.22	96.78	45.64	96.58	46.06	96.37	46.49
108	97.88	45.64	97.68	46.07	97.48	46.50	97.28	46.92
109	98.79	46.07	98.59	46.50	98.38	46.93	98.18	47.35
110	99.69	46.49	99.49	46.92	99.28	47.36	99.08	47.79
111	100.6	46.91	100.4	47.35	100.2	47.79	99.98	48.22
112	101.5	47.33	101.3	47.78	101.1	48.22	100.9	48.66
113	102.4	47.76	102.2	48.20	102.0	48.65	101.8	49.09
114	103.3	48.18	103.1	48.63	102.9	49.08	102.7	49.53
115	104.2	48.60	104.0	49.06	103.8	49.51	103.6	49.96
116	105.1	49.02	104.9	49.48	104.7	49.94	104.5	50.40
117	106.0	49.45	105.8	49.91	105.6	50.37	105.4	50.83
118	106.9	49.87	106.7	50.34	106.5	50.80	106.3	51.26
119	107.9	50.29	107.6	50.76	107.4	51.23	107.2	51.70
120	108.8	50.71	108.5	51.19	108.3	51.66	108.1	52.13
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
1	0.90	0.44	0.90	0.44	0.89	0.45	0.89	0.45
2	1.80	0.88	1.79	0.88	1.79	0.89	1.79	0.90
3	2.70	1.32	2.69	1.33	2.68	1.34	2.68	1.35
4	3.60	1.75	3.59	1.77	3.58	1.78	3.57	1.80
5	4.49	2.19	4.48	2.21	4.47	2.23	4.46	2.25
6	5.39	2.63	5.38	2.65	5.37	2.68	5.36	2.70
7	6.29	3.07	6.28	3.10	6.26	3.12	6.25	3.15
8	7.19	3.51	7.18	3.54	7.16	3.57	7.14	3.60
9	8.09	3.95	8.07	3.98	8.05	4.02	8.04	4.05
10	8.99	4.38	8.97	4.42	8.95	4.46	8.93	4.50
11	9.89	4.82	9.87	4.87	9.84	4.91	9.82	4.95
12	10.79	5.26	10.76	5.31	10.74	5.35	10.72	5.40
13	11.68	5.70	11.66	5.75	11.63	5.80	11.61	5.85
14	12.58	6.14	12.56	6.19	12.53	6.25	12.50	6.30
15	13.48	6.58	13.45	6.63	13.42	6.69	13.39	6.75
16	14.38	7.01	14.35	7.08	14.32	7.14	14.29	7.20
17	15.28	7.45	15.25	7.52	15.21	7.59	15.18	7.65
18	16.18	7.89	16.14	7.96	16.11	8.03	16.07	8.10
19	17.08	8.33	17.04	8.40	17.00	8.48	16.97	8.55
20	17.98	8.77	17.94	8.85	17.90	8.92	17.86	9.00
21	18.87	9.21	18.83	9.29	18.79	9.37	18.75	9.45
22	19.77	9.64	19.73	9.73	19.69	9.82	19.65	9.90
23	20.67	10.08	20.63	10.17	20.58	10.26	20.54	10.35
24	21.57	10.52	21.52	10.61	21.48	10.71	21.43	10.80
25	22.47	10.96	22.42	11.06	22.37	11.15	22.32	11.25
26	23.37	11.40	23.32	11.50	23.27	11.60	23.22	11.70
27	24.27	11.84	24.22	11.94	24.16	12.05	24.11	12.15
28	25.17	12.27	25.11	12.38	25.06	12.49	25.00	12.60
29	26.07	12.71	26.01	12.83	25.95	12.94	25.90	13.05
30	26.96	13.15	26.91	13.27	26.85	13.39	26.79	13.50
31	27.86	13.59	27.80	13.71	27.74	13.83	27.68	13.95
32	28.76	14.03	28.70	14.15	28.64	14.28	28.58	14.40
33	29.66	14.47	29.60	14.60	29.53	14.72	29.47	14.85
34	30.56	14.90	30.49	15.04	30.43	15.17	30.36	15.30
35	31.46	15.34	31.39	15.48	31.32	15.62	31.25	15.75
36	32.36	15.78	32.29	15.92	32.22	16.06	32.15	16.20
37	33.26	16.22	33.18	16.36	33.11	16.51	33.04	16.65
38	34.15	16.66	34.08	16.81	34.01	16.96	33.93	17.10
39	35.05	17.10	34.98	17.25	34.90	17.40	34.83	17.55
40	35.95	17.53	35.87	17.69	35.80	17.85	35.72	18.00
41	36.85	17.97	36.77	18.13	36.69	18.29	36.61	18.45
42	37.75	18.41	37.67	18.58	37.59	18.74	37.51	18.90
43	38.65	18.85	38.57	19.02	38.48	19.19	38.40	19.35
44	39.55	19.29	39.46	19.46	39.38	19.63	39.29	19.80
45	40.45	19.73	40.36	19.90	40.27	20.08	40.18	20.25
46	41.34	20.17	41.26	20.35	41.17	20.53	41.08	20.70
47	42.24	20.60	42.15	20.79	42.06	20.97	41.97	21.15
48	43.14	21.04	43.05	21.23	42.96	21.42	42.86	21.60
49	44.04	21.48	43.95	21.67	43.85	21.86	43.76	22.05
50	44.94	21.92	44.84	22.11	44.75	22.31	44.65	22.50
51	45.84	22.36	45.74	22.56	45.64	22.76	45.54	22.95
52	46.74	22.80	46.64	23.00	46.54	23.20	46.43	23.41
53	47.64	23.23	47.53	23.44	47.43	23.65	47.33	23.86
54	48.53	23.67	48.43	23.88	48.33	24.09	48.22	24.31
55	49.43	24.11	49.33	24.33	49.22	24.54	49.11	24.76
56	50.33	24.55	50.22	24.77	50.12	24.99	50.01	25.21
57	51.23	24.99	51.12	25.21	51.01	25.43	50.90	25.66
58	52.13	25.43	52.02	25.65	51.91	25.88	51.79	26.11
59	53.03	25.86	52.92	26.10	52.80	26.33	52.69	26.56
60	53.93	26.30	53.81	26.54	53.70	26.77	53.58	27.01
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
61	54.83	26.74	54.71	26.98	54.59	27.22	54.47	27.46
62	55.73	27.18	55.61	27.42	55.49	27.66	55.36	27.91
63	56.62	27.62	56.50	27.86	56.38	28.11	56.26	28.36
64	57.52	28.06	57.40	28.31	57.28	28.56	57.15	28.81
65	58.42	28.49	58.30	28.75	58.17	29.00	58.04	29.26
66	59.32	28.93	59.19	29.19	59.07	29.45	58.94	29.71
67	60.22	29.37	60.09	29.63	59.96	29.90	59.83	30.16
68	61.12	29.81	60.99	30.08	60.86	30.34	60.72	30.61
69	62.02	30.25	61.88	30.52	61.75	30.79	61.62	31.06
70	62.92	30.69	62.78	30.96	62.65	31.23	62.51	31.51
71	63.81	31.12	63.68	31.40	63.54	31.68	63.40	31.96
72	64.71	31.56	64.57	31.84	64.44	32.13	64.29	32.41
73	65.61	32.00	65.47	32.29	65.33	32.57	65.19	32.86
74	66.51	32.44	66.37	32.73	66.23	33.02	66.08	33.31
75	67.41	32.88	67.27	33.17	67.12	33.46	66.97	33.76
76	68.31	33.32	68.16	33.61	68.02	33.91	67.87	34.21
77	69.21	33.75	69.06	34.06	68.91	34.36	68.76	34.66
78	70.11	34.19	69.96	34.50	69.80	34.80	69.65	35.11
79	71.00	34.63	70.85	34.94	70.70	35.25	70.55	35.56
80	71.90	35.07	71.75	35.38	71.59	35.70	71.44	36.01
81	72.80	35.51	72.65	35.83	72.49	36.14	72.33	36.46
82	73.70	35.95	73.54	36.27	73.38	36.59	73.22	36.91
83	74.60	36.38	74.44	36.71	74.28	37.03	74.12	37.36
84	75.50	36.82	75.34	37.15	75.17	37.48	75.01	37.81
85	76.40	37.26	76.23	37.59	76.07	37.93	75.90	38.26
86	77.30	37.70	77.13	38.04	76.96	38.37	76.80	38.71
87	78.20	38.14	78.03	38.48	77.86	38.82	77.69	39.16
88	79.09	38.58	78.92	38.92	78.75	39.27	78.58	39.61
89	79.99	39.01	79.82	39.36	79.65	39.71	79.48	40.06
90	80.89	39.45	80.72	39.81	80.54	40.16	80.37	40.51
91	81.79	39.89	81.62	40.25	81.44	40.60	81.26	40.96
92	82.69	40.33	82.51	40.69	82.33	41.05	82.15	41.41
93	83.59	40.77	83.41	41.13	83.23	41.50	83.05	41.86
94	84.49	41.21	84.31	41.58	84.12	41.94	83.94	42.31
95	85.39	41.65	85.20	42.02	85.02	42.39	84.83	42.76
96	86.28	42.08	86.10	42.46	85.91	42.83	85.73	43.21
97	87.18	42.52	87.00	42.90	86.81	43.28	86.62	43.66
98	88.08	42.96	87.89	43.34	87.70	43.73	87.51	44.11
99	88.98	43.40	88.79	43.79	88.60	44.17	88.40	44.56
100	89.88	43.84	89.69	44.23	89.49	44.62	89.30	45.01
101	90.78	44.28	90.58	44.67	90.39	45.07	90.19	45.46
102	91.68	44.71	91.48	45.11	91.28	45.51	91.08	45.91
103	92.58	45.15	92.38	45.56	92.18	45.96	91.98	46.36
104	93.47	45.59	93.27	46.00	93.07	46.40	92.87	46.81
105	94.37	46.03	94.17	46.44	93.97	46.85	93.76	47.26
106	95.27	46.47	95.07	46.88	94.86	47.30	94.66	47.71
107	96.17	46.91	95.97	47.32	95.76	47.74	95.55	48.16
108	97.07	47.34	96.86	47.77	96.65	48.19	96.44	48.61
109	97.97	47.78	97.76	48.21	97.55	48.64	97.33	49.06
110	98.87	48.23	98.66	48.65	98.44	49.08	98.23	49.51
111	99.77	48.66	99.55	49.09	99.34	49.53	99.12	49.96
112	100.7	49.10	100.4	49.54	100.2	49.97	100.0	50.41
113	101.6	49.54	101.3	49.98	101.1	50.42	100.9	50.86
114	102.5	49.97	102.2	50.42	102.0	50.87	101.8	51.31
115	103.4	50.41	103.1	50.86	102.9	51.31	102.7	51.76
116	104.3	50.85	104.0	51.31	103.8	51.76	103.6	52.21
117	105.2	51.29	104.9	51.75	104.7	52.21	104.5	52.66
118	106.1	51.73	105.8	52.19	105.6	52.65	105.4	53.11
119	107.0	52.17	106.7	52.63	106.5	53.10	106.3	53.56
120	107.9	52.60	107.6	53.07	107.4	53.54	107.2	54.01
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

63 DEGREES.

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
1	0.89	0.45	0.89	0.46	0.89	0.46	0.88	0.47
2	1.78	0.91	1.78	0.92	1.77	0.92	1.77	0.93
3	2.67	1.36	2.67	1.37	2.66	1.39	2.65	1.40
4	3.56	1.82	3.56	1.83	3.55	1.85	3.54	1.86
5	4.46	2.27	4.45	2.29	4.44	2.31	4.42	2.33
6	5.35	2.72	5.33	2.75	5.32	2.77	5.31	2.79
7	6.24	3.18	6.22	3.21	6.21	3.23	6.19	3.26
8	7.13	3.63	7.11	3.66	7.10	3.69	7.08	3.72
9	8.02	4.09	8.00	4.12	7.98	4.16	7.96	4.19
10	8.91	4.54	8.89	4.58	8.87	4.62	8.85	4.66
11	9.80	4.99	9.78	5.04	9.76	5.08	9.73	5.12
12	10.69	5.45	10.67	5.49	10.64	5.54	10.62	5.59
13	11.58	5.90	11.56	5.95	11.53	6.00	11.50	6.05
14	12.47	6.36	12.45	6.41	12.42	6.46	12.39	6.52
15	13.37	6.81	13.34	6.87	13.31	6.93	13.27	6.98
16	14.26	7.26	14.22	7.33	14.19	7.39	14.16	7.45
17	15.15	7.72	15.11	7.78	15.08	7.85	15.04	7.92
18	16.04	8.17	16.00	8.24	15.97	8.31	15.93	8.38
19	16.93	8.63	16.89	8.70	16.85	8.77	16.81	8.85
20	17.82	9.08	17.78	9.16	17.74	9.24	17.70	9.31
21	18.71	9.53	18.67	9.62	18.63	9.70	18.58	9.78
22	19.60	9.99	19.56	10.07	19.51	10.16	19.47	10.24
23	20.49	10.44	20.45	10.53	20.40	10.62	20.35	10.71
24	21.38	10.90	21.34	10.99	21.29	11.08	21.24	11.17
25	22.28	11.35	22.23	11.45	22.18	11.54	22.12	11.64
26	23.17	11.80	23.11	11.90	23.06	12.01	23.01	12.11
27	24.06	12.26	24.00	12.36	23.95	12.47	23.89	12.57
28	24.95	12.71	24.89	12.82	24.84	12.93	24.78	13.04
29	25.84	13.17	25.78	13.28	25.72	13.39	25.66	13.50
30	26.73	13.62	26.67	13.74	26.61	13.85	26.55	13.97
31	27.62	14.07	27.56	14.19	27.50	14.31	27.43	14.43
32	28.51	14.53	28.45	14.65	28.38	14.78	28.32	14.90
33	29.40	14.98	29.34	15.11	29.27	15.24	29.20	15.37
34	30.29	15.44	30.23	15.57	30.16	15.70	30.09	15.83
35	31.19	15.89	31.12	16.03	31.05	16.16	30.97	16.30
36	32.08	16.34	32.00	16.48	31.93	16.62	31.86	16.76
37	32.97	16.80	32.89	16.94	32.82	17.08	32.74	17.23
38	33.86	17.25	33.78	17.40	33.71	17.55	33.63	17.69
39	34.75	17.71	34.67	17.86	34.59	18.01	34.51	18.16
40	35.64	18.16	35.56	18.32	35.48	18.47	35.40	18.62
41	36.53	18.61	36.45	18.77	36.37	18.93	36.28	19.09
42	37.42	19.07	37.34	19.23	37.25	19.39	37.17	19.56
43	38.31	19.52	38.23	19.69	38.14	19.86	38.05	20.02
44	39.20	19.98	39.12	20.15	39.03	20.32	38.94	20.49
45	40.10	20.43	40.01	20.60	39.92	20.78	39.82	20.95
46	40.99	20.88	40.89	21.06	40.80	21.24	40.71	21.42
47	41.88	21.34	41.78	21.52	41.69	21.70	41.59	21.88
48	42.77	21.79	42.67	21.98	42.58	22.16	42.48	22.35
49	43.66	22.25	43.56	22.44	43.46	22.63	43.36	22.82
50	44.55	22.70	44.45	22.89	44.35	23.09	44.25	23.28
51	45.44	23.15	45.34	23.35	45.24	23.55	45.13	23.75
52	46.33	23.61	46.23	23.81	46.12	24.01	46.02	24.21
53	47.22	24.06	47.12	24.27	47.01	24.47	46.90	24.68
54	48.11	24.52	48.01	24.73	47.90	24.93	47.79	25.14
55	49.01	24.97	48.90	25.18	48.79	25.40	48.67	25.61
56	49.90	25.42	49.78	25.64	49.67	25.86	49.56	26.07
57	50.79	25.88	50.67	26.10	50.56	26.32	50.44	26.54
58	51.68	26.33	51.56	26.56	51.45	26.78	51.33	27.01
59	52.57	26.79	52.45	27.01	52.33	27.24	52.21	27.47
60	53.46	27.24	53.34	27.47	53.22	27.70	53.10	27.94
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep.	15′ Lat	15′ Dep.	30′ Lat.	30′ Dep	45′ Lat	45′ Dep.
61	54.35	27.69	54.23	27.93	54.11	28.17	53.98	28.40
62	55.24	28.15	55.12	28.39	54.99	28.63	54.87	28.87
63	56.13	28.60	56.01	28.85	55.88	29.09	55.75	29.33
64	57.02	29.06	56.90	29.30	56.77	29.55	56.64	29.80
65	57.92	29.51	57.79	29.76	57.66	30.01	57.52	30.26
66	58.81	29.96	58.68	30.22	58.54	30.48	58.41	30.73
67	59.70	30.42	59.56	30.68	59.43	30.94	59.29	31.20
68	60.59	30.87	60.45	31.14	60.32	31.40	60.18	31.66
69	61.48	31.33	61.34	31.59	61.20	31.86	61.06	32.13
70	62.37	31.78	62.23	32.05	62.09	32.32	61.95	32.59
71	63.26	32.23	63.12	32.51	62.98	32.78	62.83	33.06
72	64.15	32.69	64.01	32.97	63.86	33.25	63.72	33.52
73	65.04	33.14	64.90	33.42	64.75	33.71	64.60	33.99
74	65.93	33.60	65.79	33.88	65.64	34.17	65.49	34.46
75	66.83	34.05	66.68	34.34	66.53	34.63	66.37	34.92
76	67.72	34.50	67.57	34.80	67.41	35.09	67.26	35.39
77	68.61	34.96	68.45	35.26	68.30	35.55	68.14	35.85
78	69.50	35.41	69.34	35.71	69.19	36.02	69.03	36.32
79	70.39	35.87	70.23	36.17	70.07	36.48	69.91	36.78
80	71.28	36.32	71.12	36.63	70.96	36.94	70.80	37.25
81	72.17	36.77	72.01	37.09	71.85	37.40	71.68	37.71
82	73.06	37.23	72.90	37.55	72.73	37.86	72.57	38.18
83	73.95	37.68	73.79	38.00	73.62	38.33	73.45	38.65
84	74.84	38.14	74.68	38.46	74.51	38.79	74.34	39.11
85	75.74	38.59	75.57	38.92	75.40	39.25	75.22	39.58
86	76.63	39.04	76.46	39.38	76.28	39.71	76.11	40.04
87	77.52	39.50	77.34	39.84	77.17	40.17	76.99	40.51
88	78.41	39.95	78.23	40.29	78.06	40.63	77.88	40.97
89	79.30	40.41	79.12	40.75	78.94	41.10	78.76	41.44
90	80.19	40.86	80.01	41.21	79.83	41.56	79.65	41.91
91	81.08	41.31	80.90	41.67	80.72	42.02	80.53	42.37
92	81.97	41.77	81.79	42.12	81.61	42.48	81.42	42.84
93	82.86	42.22	82.68	42.58	82.49	42.94	82.30	43.30
94	83.75	42.68	83.57	43.04	83.38	43.40	83.19	43.77
95	84.65	43.13	84.46	43.50	84.27	43.87	84.07	44.23
96	85.54	43.58	85.35	43.96	85.15	44.33	84.96	44.70
97	86.43	44.04	86.23	44.41	86.04	44.79	85.84	45.16
98	87.32	44.49	87.12	44.87	86.93	45.25	86.73	45.63
99	88.21	44.95	88.01	45.33	87.81	45.71	87.61	46.10
100	89.10	45.40	88.90	45.79	88.70	46.17	88.50	46.56
101	89.99	45.85	89.79	46.25	89.59	46.64	89.38	47.03
102	90.88	46.31	90.68	46.70	90.48	47.10	90.27	47.49
103	91.77	46.76	91.57	47.16	91.36	47.56	91.15	47.96
104	92.66	47.22	92.46	47.62	92.25	48.02	92.04	48.42
105	93.56	47.67	93.35	48.08	93.14	48.48	92.92	48.89
106	94.45	48.12	94.24	48.53	94.02	48.95	93.81	49.36
107	95.34	48.58	95.12	48.99	94.91	49.41	94.69	49.82
108	96.23	49.03	96.01	49.45	95.80	49.87	95.58	50.29
109	97.12	49.49	96.90	49.91	96.68	50.33	96.46	50.75
110	98.01	49.94	97.79	50.37	97.57	50.79	97.35	51.22
111	98.90	50.39	98.68	50.82	98.46	51.25	98.23	51.68
112	99.79	50.85	99.57	51.28	99.35	51.72	99.12	52.15
113	100.7	51.30	100.5	51.74	100.2	52.18	100.0	52.61
114	101.6	51.76	101.3	52.20	101.1	52.64	100.9	53.08
115	102.5	52.21	102.2	52.66	102.0	53.10	101.8	53.55
116	103.4	52.66	103.1	53.11	102.9	53.56	102.7	54.01
117	104.2	53.12	104.0	53.57	103.8	54.02	103.5	54.48
118	105.1	53.57	104.9	54.03	104.7	54.49	104.4	54.94
119	106.0	54.02	105.8	54.49	105.6	54.95	105.3	55.41
120	106.9	54.48	106.7	54.94	106.4	55.41	106.2	55.87
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0' Lat	0' Dep.	15' Lat.	15' Dep.	30' Lat.	30' Dep.	45' Lat.	45' Dep.
1	0.88	0.47	0.88	0.47	0.88	0.48	0.88	0.48
2	1.77	0.94	1.76	0.95	1.76	0.95	1.75	0.96
3	2.65	1.41	2.64	1.42	2.64	1.43	2.63	1.44
4	3.53	1.88	3.52	1.89	3.52	1.91	3.51	1.92
5	4.41	2.35	4.40	2.37	4.39	2.39	4.38	2.40
6	5.30	2.82	5.29	2.84	5.27	2.86	5.26	2.89
7	6.18	3.29	6.17	3.31	6.15	3.34	6.14	3.37
8	7.06	3.76	7.05	3.79	7.03	3.82	7.01	3.85
9	7.95	4.23	7.93	4.26	7.91	4.29	7.89	4.33
10	8.83	4.69	8.81	4.73	8.79	4.77	8.77	4.81
11	9.71	5.16	9.69	5.21	9.67	5.25	9.64	5.29
12	10.60	5.63	10.57	5.68	10.55	5.73	10.52	5.77
13	11.48	6.10	11.45	6.15	11.42	6.20	11.40	6.25
14	12.36	6.57	12.33	6.63	12.30	6.68	12.27	6.73
15	13.24	7.04	13.21	7.10	13.18	7.16	13.15	7.21
16	14.13	7.51	14.09	7.57	14.06	7.63	14.03	7.70
17	15.01	7.98	14.98	8.05	14.94	8.11	14.90	8.18
18	15.89	8.45	15.86	8.52	15.82	8.59	15.78	8.66
19	16.78	8.92	16.74	8.99	16.70	9.07	16.66	9.14
20	17.66	9.39	17.62	9.47	17.58	9.54	17.53	9.62
21	18.54	9.86	18.50	9.94	18.46	10.02	18.41	10.10
22	19.42	10.33	19.38	10.41	19.33	10.50	19.29	10.58
23	20.31	10.80	20.26	10.89	20.21	10.97	20.16	11.06
24	21.19	11.27	21.14	11.36	21.09	11.45	21.04	11.54
25	22.07	11.74	22.02	11.83	21.97	11.93	21.92	12.02
26	22.96	12.21	22.90	12.31	22.85	12.41	22.79	12.51
27	23.84	12.68	23.78	12.78	23.73	12.88	23.67	12.99
28	24.72	13.15	24.66	13.25	24.61	13.36	24.55	13.47
29	25.61	13.61	25.55	13.73	25.49	13.84	25.43	13.95
30	26.49	14.08	26.43	14.20	26.36	14.31	26.30	14.43
31	27.37	14.55	27.31	14.67	27.24	14.79	27.18	14.91
32	28.25	15.02	28.19	15.15	28.12	15.27	28.06	15.39
33	29.14	15.49	29.07	15.62	29.00	15.75	28.93	15.87
34	30.02	15.96	29.95	16.09	29.88	16.22	29.81	16.35
35	30.90	16.43	30.83	16.57	30.76	16.70	30.69	16.83
36	31.79	16.90	31.71	17.04	31.64	17.18	31.56	17.32
37	32.67	17.37	32.59	17.51	32.52	17.65	32.44	17.80
38	33.55	17.84	33.47	17.99	33.40	18.13	33.32	18.28
39	34.44	18.31	34.35	18.46	34.27	18.61	34.19	18.76
40	35.32	18.78	35.24	18.93	35.15	19.09	35.07	19.24
41	36.20	19.25	36.12	19.41	36.03	19.56	35.95	19.72
42	37.08	19.72	37.00	19.88	36.91	20.04	36.82	20.20
43	37.97	20.19	37.88	20.35	37.79	20.52	37.70	20.68
44	38.85	20.66	38.76	20.83	38.67	20.99	38.58	21.16
45	39.73	21.13	39.64	21.30	39.55	21.47	39.45	21.64
46	40.62	21.60	40.52	21.77	40.43	21.95	40.33	22.13
47	41.50	22.07	41.40	22.25	41.30	22.43	41.21	22.61
48	42.38	22.54	42.28	22.72	42.18	22.90	42.08	23.09
49	43.26	23.00	43.16	23.19	43.06	23.38	42.96	23.57
50	44.15	23.47	44.04	23.67	43.94	23.86	43.84	24.05
51	45.03	23.94	44.93	24.14	44.82	24.34	44.71	24.53
52	45.91	24.41	45.81	24.61	45.70	24.81	45.59	25.01
53	46.80	24.88	46.69	25.09	46.58	25.29	46.47	25.49
54	47.68	25.35	47.57	25.56	47.46	25.77	47.34	25.97
55	48.56	25.82	48.45	26.03	48.33	26.24	48.22	26.45
56	49.45	26.29	49.33	26.51	49.21	26.72	49.10	26.94
57	50.33	26.76	50.21	26.98	50.09	27.20	49.97	27.42
58	51.21	27.23	51.09	27.45	50.97	27.68	50.85	27.90
59	52.09	27.70	51.97	27.93	51.85	28.15	51.73	28.38
60	52.98	28.17	52.85	28.40	52.73	28.63	52.60	28.86
Dist.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0'		45'		30'		15'	

Dist.	0′ Lat	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat	45′ Dep.
61	53.86	28.64	53.73	28.87	53.61	29.11	53.48	29.34
62	54.74	29.11	54.62	29.35	54.49	29.58	54.36	29.8[illegible]
63	55.63	29.58	55.50	29.82	55.37	30.06	55.23	30.3[illegible]
64	56.51	30.05	56.38	30.29	56.24	30.54	56.11	30.7[illegible]
65	57.39	30.52	57.26	30.77	57.12	31.02	56.99	31.2[illegible]
66	58.27	30.99	58.14	31.24	58.00	31.49	57.86	31.7[illegible]
67	59.16	31.45	59.02	31.71	58.88	31.97	58.74	32.2[illegible]
68	60.04	31.92	59.90	32.19	59.76	32.45	59.62	32[illegible]
69	60.92	32.39	60.78	32.66	60.64	32.92	60.49	33[illegible]
70	61.81	32.86	61.66	33.13	61.52	33.40	61.37	33.6[illegible]
71	62.69	33.33	62.54	33.61	62.40	33.88	62.25	34.1[illegible]
72	63.57	33.80	63.42	34.08	63.27	34.36	63.12	34.6[illegible]
73	64.46	34.27	64.31	34.55	64.15	34.83	64.00	35.1[illegible]
74	65.34	34.74	65.19	35.03	65.03	35.31	64.88	35.59
75	66.22	35.21	66.07	35.50	65.91	35.79	65.75	36.07
76	67.10	35.68	66.95	35.97	66.79	36.26	66.63	36.56
77	67.99	36.15	67.83	36.45	67.67	36.74	67.51	37.04
78	68.87	36.62	68.71	36.92	68.55	37.22	68.38	37.52
79	69.75	37.09	69.59	37.39	69.43	37.70	69.26	38.00
80	70.64	37.56	70.47	37.87	70.31	38.17	70.14	38.48
81	71.52	38.03	71.35	38.34	71.18	38.65	71.01	38.96
82	72.40	38.50	72.23	38.81	72.06	39.13	71.89	39.44
83	73.28	38.97	73.11	39.29	72.94	39.60	72.77	39.92
84	74.17	39.44	73.99	39.76	73.82	40.08	73.65	40.40
85	75.05	39.91	74.88	40.23	74.70	40.56	74.52	40.88
86	75.93	40.37	75.76	40.71	75.58	41.04	75.40	41.37
87	76.82	40.84	76.64	41.18	76.46	41.51	76.28	41.85
88	77.70	41.31	77.52	41.65	77.34	41.99	77.15	42.33
89	78.58	41.78	78.40	42.13	78.21	42.47	78.03	42.81
90	79.47	42.25	79.28	42.60	79.09	42.94	78.91	43.29
91	80.35	42.72	80.16	43.07	79.97	43.42	79.78	43.77
92	81.23	43.19	81.04	43.55	80.85	43.90	80.66	44.25
93	82.11	43.66	81.92	44.02	81.73	44.38	81.54	44.73
94	83.00	44.13	82.80	44.49	82.61	44.85	82.41	45.21
95	83.88	44.60	83.68	44.97	83.49	45.33	83.29	45.69
96	84.76	45.07	84.57	45.44	84.37	45.81	84.17	46.17
97	85.65	45.54	85.45	45.91	85.25	46.28	85.04	46.66
98	86.53	46.01	86.33	46.39	86.12	46.76	85.92	47.14
99	87.41	46.48	87.21	46.86	87.00	47.24	86.80	47.62
100	88.29	46.95	88.09	47.33	87.88	47.72	87.67	48.10
101	89.18	47.42	88.97	47.81	88.76	48.16	88.55	48.58
102	90.06	47.89	89.85	48.28	89.64	48.67	89.43	49.06
103	91.94	48.36	90.73	48.75	90.52	49.15	90.30	49.54
104	91.83	48.82	91.61	49.23	91.40	49.62	91.18	50.02
105	92.71	49.29	92.49	49.70	92.28	50.10	92.06	50.50
106	93.59	49.76	93.37	50.17	93.15	50.58	92.93	50.98
107	94.48	50.23	94.26	50.65	94.03	51.06	93.81	51.47
108	95.36	50.70	95.14	51.12	94.91	51.53	94.69	51.95
109	96.24	51.17	96.02	51.59	95.79	52.01	95.56	52.43
110	97.12	51.64	96.90	52.07	96.67	52.49	96.44	52.91
111	98.01	52.11	97.78	52.54	97.55	52.96	97.32	53.39
112	98.89	52.58	98.66	53.01	98.43	53.44	98.19	53.87
113	99.77	53.05	99.54	53.49	99.31	53.92	99.07	54.35
114	100.7	53.52	100.4	53.96	100.2	54.40	99.95	54.83
115	101.5	53.99	101.3	54.43	101.1	54.87	100.8	55.31
116	102.4	54.46	102.2	54.90	101.9	55.35	101.7	55.79
117	103.3	54.93	103.1	55.38	102.8	55.83	102.6	56.28
118	104.2	55.40	103.9	55.85	103.7	56.30	103.5	56.76
119	105.1	55.87	104.8	56.33	104.6	56.78	104.3	57.24
120	106.0	56.34	105.7	56.80	105.5	57.26	105.2	57.72
Dist.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
1	0.87	0.48	0.87	0.49	0.87	0.49	0.87	0.50
2	1.75	0.97	1.75	0.98	1.74	0.98	1.74	0.99
3	2.62	1.45	2.62	1.47	2.61	1.48	2.60	1.49
4	3.50	1.94	3.49	1.95	3.48	1.97	3.47	1.98
5	4.37	2.42	4.36	2.44	4.35	2.46	4.34	2.48
6	5.25	2.91	5.24	2.93	5.22	2.95	5.21	2.98
7	6.12	3.39	6.11	3.42	6.09	3.45	6.08	3.47
8	7.00	3.88	6.98	3.91	6.96	3.94	6.95	3.97
9	7.87	4.36	7.85	4.40	7.83	4.43	7.81	4.47
10	8.75	4.85	8.73	4.89	8.70	4.92	8.68	4.96
11	9.62	5.33	9.60	5.37	9.57	5.42	9.55	5.46
12	10.50	5.82	10.47	5.86	10.44	5.91	10.42	5.95
13	11.37	6.30	11.34	6.35	11.31	6.40	11.29	6.45
14	12.24	6.79	12.21	6.84	12.18	6.89	12.15	6.95
15	13.12	7.27	13.09	7.33	13.06	7.39	13.02	7.44
16	13.99	7.76	13.96	7.82	13.93	7.88	13.89	7.94
17	14.87	8.24	14.83	8.31	14.80	8.37	14.76	8.44
18	15.74	8.73	15.70	8.80	15.67	8.86	15.63	8.93
19	16.62	9.21	16.58	9.28	16.54	9.36	16.50	9.43
20	17.49	9.70	17.45	9.77	17.41	9.85	17.36	9.92
21	18.37	10.18	18.32	10.26	18.28	10.34	18.23	10.42
22	19.24	10.67	19.19	10.75	19.15	10.83	19.10	10.92
23	20.12	11.15	20.07	11.24	20.02	11.33	19.97	11.41
24	20.99	11.64	20.94	11.73	20.89	11.82	20.84	11.91
25	21.87	12.12	21.81	12.22	21.76	12.31	21.70	12.41
26	22.74	12.61	22.68	12.70	22.63	12.80	22.57	12.90
27	23.61	13.09	23.56	13.19	23.50	13.30	23.44	13.40
28	24.49	13.57	24.43	13.68	24.37	13.79	24.31	13.89
29	25.36	14.06	25.30	14.17	25.24	14.28	25.18	14.39
30	26.24	14.54	26.17	14.66	26.11	14.77	26.05	14.89
31	27.11	15.03	27.05	15.15	26.98	15.27	26.91	15.38
32	27.99	15.51	27.92	15.64	27.85	15.76	27.78	15.88
33	28.86	16.00	28.79	16.12	28.72	16.25	28.65	16.38
34	29.74	16.48	29.66	16.61	29.59	16.74	29.52	16.87
35	30.61	16.97	30.54	17.10	30.46	17.23	30.39	17.37
36	31.49	17.45	31.41	17.59	31.33	17.73	31.26	17.86
37	32.36	17.94	32.28	18.08	32.20	18.22	32.12	18.36
38	33.24	18.42	33.15	18.57	33.07	18.71	32.99	18.86
39	34.11	18.91	34.03	19.06	33.94	19.20	33.86	19.35
40	34.98	19.39	34.90	19.54	34.81	19.70	34.73	19.85
41	35.86	19.88	35.77	20.03	35.68	20.19	35.60	20.34
42	36.73	20.36	36.64	20.52	36.55	20.68	36.46	20.84
43	37.61	20.85	37.52	21.01	37.43	21.17	37.33	21.34
44	38.48	21.33	38.39	21.50	38.30	21.67	38.20	21.83
45	39.36	21.82	39.26	21.99	39.17	22.16	39.07	22.33
46	40.23	22.30	40.13	22.48	40.04	22.65	39.94	22.83
47	41.11	22.79	41.01	22.97	40.91	23.14	40.81	23.32
48	41.98	23.27	41.88	23.45	41.78	23.64	41.67	23.82
49	42.86	23.76	42.75	23.94	42.65	24.13	42.54	24.31
50	43.73	24.24	43.62	24.43	43.52	24.62	43.41	24.81
51	44.61	24.73	44.50	24.92	44.39	25.11	44.28	25.31
52	45.48	25.21	45.37	25.41	45.26	25.61	45.15	25.80
53	46.35	25.69	46.24	25.90	46.13	26.10	46.01	26.30
54	47.23	26.18	47.11	26.39	47.00	26.59	46.88	26.80
55	48.10	26.66	47.99	26.87	47.87	27.08	47.75	27.29
56	48.98	27.15	48.86	27.36	48.74	27.58	48.62	27.79
57	49.85	27.63	49.73	27.85	49.61	28.07	49.49	28.28
58	50.73	28.12	50.60	28.34	50.48	28.56	50.36	28.78
59	51.60	28.60	51.48	28.83	51.35	29.05	51.22	29.28
60	52.48	29.09	52.35	29.32	52.22	29.55	52.09	29.77
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
61	53.35	29.57	53.22	29.81	53.09	30.04	52.96	30.27
62	54.23	30.06	54.09	30.29	53.96	30.53	53.83	30.77
63	55.10	30.54	54.97	30.78	54.83	31.02	54.70	31.26
64	55.98	31.03	55.84	31.27	55.70	31.52	55.56	31.76
65	56.85	31.51	56.71	31.76	56.57	32.01	56.43	32.25
66	57.72	32.00	57.58	32.25	57.44	32.50	57.30	32.75
67	58.60	32.48	58.46	32.74	58.31	32.99	58.17	33.25
68	59.47	32.97	59.33	33.23	59.18	33.48	59.04	33.74
69	60.35	33.45	60.20	33.71	60.05	33.98	59.91	34.24
70	61.22	33.94	61.07	34.20	60.92	34.47	60.77	34.74
71	62.10	34.42	61.95	34.69	61.80	34.96	61.64	35.23
72	62.97	34.91	62.82	35.18	62.67	35.45	62.51	35.73
73	63.85	35.39	63.69	35.67	63.54	35.95	63.38	36.22
74	64.72	35.88	64.56	36.16	64.41	36.44	64.25	36.72
75	65.60	36.36	65.44	36.65	65.28	36.93	65.11	37.22
76	66.47	36.85	66.31	37.14	66.15	37.42	65.98	37.71
77	67.35	37.33	67.18	37.62	67.02	37.92	66.85	38.21
78	68.22	37.82	68.05	38.11	67.89	38.41	67.72	38.70
79	69.09	38.30	68.93	38.60	68.76	38.90	68.59	39.20
80	69.97	38.78	69.80	39.09	69.63	39.39	69.46	39.70
81	70.84	39.27	70.67	39.58	70.50	39.89	70.32	40.19
82	71.72	39.75	71.54	40.07	71.37	40.38	71.19	40.69
83	72.59	40.24	72.42	40.56	72.24	40.87	72.06	41.19
84	73.47	40.72	73.29	41.04	73.11	41.36	72.93	41.68
85	74.34	41.21	74.16	41.53	73.98	41.86	73.80	42.18
86	75.22	41.69	75.03	42.02	74.85	42.35	74.67	42.67
87	76.09	42.18	75.91	42.51	75.72	42.84	75.53	43.17
88	76.97	42.66	76.78	43.00	76.59	43.33	76.40	43.67
89	77.84	43.15	77.65	43.49	77.46	43.83	77.27	44.16
90	78.72	43.63	78.52	43.98	78.33	44.32	78.14	44.66
91	79.59	44.12	79.40	44.46	79.20	44.81	79.01	45.16
92	80.47	44.60	80.27	44.95	80.07	45.30	79.87	45.65
93	81.34	45.09	81.14	45.44	80.94	45.80	80.74	46.15
94	82.21	45.57	82.01	45.93	81.81	46.29	81.61	46.64
95	83.09	46.06	82.89	46.42	82.68	46.78	82.48	47.14
96	83.96	46.54	83.76	46.91	83.55	47.27	83.35	47.64
97	84.84	47.03	84.63	47.40	84.42	47.77	84.22	48.13
98	85.71	47.51	85.50	47.88	85.29	48.26	85.08	48.63
99	86.59	48.00	86.38	48.37	86.17	48.75	85.95	49.13
100	87.46	48.48	87.25	48.86	87.04	49.24	86.82	49.62
101	88.34	48.97	88.12	49.35	87.91	49.73	87.69	50.12
102	89.21	49.45	88.99	49.84	88.78	50.23	88.56	50.61
103	90.09	49.94	89.87	50.33	89.65	50.72	89.42	51.11
104	90.96	50.42	90.74	50.82	90.52	51.21	90.29	51.61
105	91.84	50.91	91.61	51.31	91.39	51.70	91.16	52.10
106	92.71	51.39	92.48	51.79	92.26	52.20	92.03	52.60
107	93.58	51.87	93.36	52.28	93.13	52.69	92.90	53.10
108	94.46	52.36	94.23	52.77	94.00	53.18	93.77	53.59
109	95.33	52.84	95.10	53.26	94.87	53.67	94.63	54.09
110	96.21	53.33	95.97	53.75	95.74	54.17	95.50	54.58
111	97.08	53.81	96.85	54.24	96.61	54.66	96.37	55.08
112	97.96	54.30	97.72	54.73	97.48	55.15	97.24	55.58
113	98.83	54.78	98.59	55.21	98.35	55.64	98.11	56.07
114	99.71	55.27	99.46	55.70	99.22	56.14	98.97	56.57
115	100.6	55.75	100.3	56.19	100.1	56.63	99.84	57.06
116	101.5	56.24	101.2	56.68	101.0	57.12	100.7	57.56
117	102.3	56.72	102.1	57.17	101.8	57.61	101.6	58.06
118	103.2	57.21	103.0	57.66	102.7	58.11	102.4	58.55
119	104.1	57.69	103.8	58.15	103.6	58.60	103.3	59.05
120	105.0	58.18	104.7	58.63	104.4	59.09	104.2	59.55
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

60 DEGREES.

Dist.	0′		15′		30′		45′	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
1	0.87	0.50	0.86	0.50	0.86	0.51	0.86	0.51
2	1.73	1.00	1.73	1.01	1.72	1.02	1.72	1.02
3	2.60	1.50	2.59	1.51	2.58	1.52	2.58	1.53
4	3.46	2.00	3.46	2.02	3.45	2.03	3.44	2.05
5	4.33	2.50	4.32	2.52	4.31	2.54	4.30	2.56
6	5.20	3.00	5.18	3.02	5.17	3.05	5.16	3.07
7	6.06	3.50	6.05	3.53	6.03	3.55	6.02	3.58
8	6.93	4.00	6.92	4.03	6.89	4.06	6.88	4.09
9	7.79	4.50	7.77	4.53	7.75	4.57	7.73	4.60
10	8.66	5.00	8.64	5.04	8.62	5.08	8.59	5.11
11	9.53	5.50	9.50	5.54	9.48	5.58	9.45	5.62
12	10.39	6.00	10.37	6.05	10.34	6.09	10.31	6.14
13	11.26	6.50	11.23	6.55	11.20	6.60	11.17	6.65
14	12.12	7.00	12.09	7.05	12.06	7.11	12.03	7.16
15	12.99	7.50	12.96	7.56	12.92	7.61	12.89	7.67
16	13.86	8.00	13.82	8.06	13.79	8.12	13.75	8.18
17	14.72	8.50	14.69	8.56	14.65	8.63	14.61	8.69
18	15.59	9.00	15.55	9.07	15.51	9.14	15.47	9.20
19	16.45	9.50	16.41	9.57	16.37	9.64	16.33	9.71
20	17.32	10.00	17.28	10.08	17.23	10.15	17.19	10.23
21	18.19	10.50	18.14	10.58	18.09	10.66	18.05	10.74
22	19.05	11.00	19.00	11.08	18.96	11.17	18.91	11.25
23	19.92	11.50	19.87	11.59	19.82	11.67	19.77	11.76
24	20.78	12.00	20.73	12.09	20.68	12.18	20.63	12.27
25	21.65	12.50	21.60	12.59	21.54	12.69	21.49	12.78
26	22.52	13.00	22.46	13.10	22.40	13.20	22.34	13.29
27	23.38	13.50	23.32	13.60	23.26	13.70	23.20	13.80
28	24.25	14.00	24.19	14.11	24.13	14.21	24.06	14.32
29	25.11	14.50	25.05	14.61	24.99	14.72	24.92	14.83
30	25.98	15.00	25.92	15.11	25.85	15.23	25.78	15.34
31	26.85	15.50	26.78	15.62	26.71	15.73	26.64	15.85
32	27.71	16.00	27.64	16.12	27.57	16.24	27.50	16.36
33	28.58	16.50	28.51	16.63	28.43	16.75	28.36	16.87
34	29.44	17.00	29.37	17.13	29.30	17.26	29.22	17.38
35	30.31	17.50	30.23	17.63	30.16	17.76	30.08	17.90
36	31.18	18.00	31.10	18.14	31.02	18.27	30.94	18.41
37	32.04	18.50	31.96	18.64	31.88	18.78	31.80	18.92
38	32.91	19.00	32.83	19.14	32.74	19.29	32.66	19.43
39	33.77	19.50	33.69	19.65	33.60	19.79	33.52	19.94
40	34.64	20.00	34.55	20.15	34.47	20.30	34.38	20.45
41	35.51	20.50	35.42	20.65	35.33	20.81	35.24	20.96
42	36.37	21.00	36.28	21.16	36.19	21.32	36.10	21.47
43	37.24	21.50	37.14	21.66	37.05	21.82	36.95	21.99
44	38.11	22.00	38.01	22.17	37.91	22.33	37.81	22.50
45	38.97	22.50	38.87	22.67	38.77	22.84	38.67	23.01
46	39.84	23.00	39.74	23.17	39.63	23.35	39.53	23.52
47	40.70	23.50	40.60	23.68	40.50	23.85	40.39	24.03
48	41.57	24.00	41.46	24.18	41.36	24.36	41.25	24.54
49	42.44	24.50	42.33	24.68	42.22	24.87	42.11	25.05
50	43.30	25.00	43.19	25.19	43.08	25.38	42.97	25.56
51	44.17	25.50	44.06	25.69	43.94	25.88	43.83	26.08
52	45.03	26.00	44.92	26.20	44.80	26.39	44.69	26.59
53	45.90	26.50	45.78	26.70	45.67	26.90	45.55	27.10
54	46.77	27.00	46.65	27.20	46.53	27.41	46.41	27.61
55	47.63	27.50	47.51	27.71	47.39	27.91	47.27	28.12
56	48.50	28.00	48.37	28.21	48.25	28.42	48.13	28.63
57	49.36	28.50	49.24	28.72	49.11	28.93	48.99	29.14
58	50.23	29.00	50.10	29.22	49.97	29.44	49.85	29.65
59	51.10	29.50	50.97	29.72	50.84	29.94	50.70	30.17
60	51.96	30.00	51.83	30.23	51.70	30.45	51.56	30.68
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0' Lat.	0' Dep	15' Lat.	15' Dep.	30' Lat.	30' Dep.	45' Lat	45' Dep.
61	52.83	30.50	52.69	30.73	52.56	30.96	52.42	31.19
62	53.69	31.00	53.56	31.23	53.42	31.47	53.28	31.70
63	54.56	31.50	54.42	31.74	54.28	31.97	54.14	32.21
64	55.43	32.00	55.29	32.24	55.14	32.48	55.00	32.72
65	56.29	32.50	56.15	32.75	56.01	32.99	55.86	33.23
66	57.16	33.00	57.01	33.25	56.87	33.50	56.72	33.75
67	58.02	33.50	57.88	33.75	57.73	34.01	57.58	34.26
68	58.89	34.00	58.74	34.26	58.59	34.51	58.44	34.77
69	59.76	34.50	59.60	34.76	59.45	35.02	59.30	35.28
70	60.62	35.00	60.47	35.26	60.31	35.53	60.16	35.79
71	61.49	35.50	61.33	35.77	61.18	36.04	61.02	36.30
72	62.35	36.00	62.20	36.27	62.04	36.54	61.88	36.81
73	63.22	36.50	63.06	36.78	62.90	37.05	62.74	37.32
74	64.09	37.00	63.92	37.28	63.76	37.56	63.60	37.84
75	64.95	37.50	64.79	37.78	64.62	38.07	64.46	38.35
76	65.82	38.00	65.65	38.29	65.48	38.57	65.31	38.86
77	66.68	38.50	66.52	38.79	66.35	39.08	66.17	39.37
78	67.55	39.00	67.38	39.29	67.21	39.59	67.03	39.88
79	68.42	39.50	68.24	39.80	68.07	40.10	67.89	40.39
80	69.28	40.00	69.11	40.30	68.93	40.60	68.75	40.90
81	70.15	40.50	69.97	40.81	69.79	41.11	69.61	41.41
82	71.01	41.00	70.83	41.31	70.65	41.62	70.47	41.93
83	71.88	41.50	71.70	41.81	71.52	42.13	71.33	42.44
84	72.75	42.00	72.56	42.32	72.38	42.63	72.19	42.95
85	73.61	42.50	73.43	42.82	73.24	43.14	73.05	43.46
86	74.48	43.00	74.29	43.32	74.10	43.65	73.91	43.97
87	75.34	43.50	75.15	43.83	74.96	44.16	74.77	44.48
88	76.21	44.00	76.02	44.33	75.82	44.66	75.63	44.99
89	77.08	44.50	76.88	44.84	76.69	45.17	76.49	45.51
90	77.94	45.00	77.75	45.34	77.55	45.68	77.35	46.02
91	78.81	45.50	78.61	45.84	78.41	46.19	78.21	46.53
92	79.67	46.00	79.47	46.35	79.27	46.69	79.07	47.04
93	80.54	46.50	80.34	46.85	80.13	47.20	79.92	47.55
94	81.41	47.00	81.20	47.35	80.99	47.71	80.78	48.06
95	82.27	47.50	82.06	47.86	81.85	48.22	81.64	48.57
96	83.14	48.00	82.93	48.36	82.72	48.72	82.50	49.08
97	84.00	48.50	83.79	48.87	83.58	49.23	83.36	49.60
98	84.87	49.00	84.66	49.37	84.44	49.74	84.22	50.11
99	85.74	49.50	85.52	49.87	85.30	50.25	85.08	50.62
100	86.60	50.00	86.38	50.38	86.16	50.75	85.94	51.13
101	87.47	50.50	87.25	50.88	87.02	51.26	86.80	51.64
102	88.33	51.00	88.11	51.38	87.89	51.77	87.66	52.15
103	89.20	51.50	88.97	51.89	88.75	52.28	88.52	52.66
104	90.07	52.00	89.84	52.39	89.61	52.78	89.38	53.17
105	90.93	52.50	90.70	52.90	90.47	53.29	90.24	53.69
106	91.80	53.00	91.57	53.40	91.33	53.80	91.10	54.20
107	92.66	53.50	92.43	53.90	92.19	54.31	91.96	54.71
108	93.53	54.00	93.29	54.41	93.06	54.81	92.82	55.22
109	94.40	54.50	94.16	54.91	93.92	55.32	93.68	55.73
110	95.26	55.00	95.02	55.42	94.78	55.83	94.53	56.24
111	96.13	55.50	95.89	55.92	95.64	56.34	95.39	56.75
112	96.99	56.00	96.75	56.42	96.50	56.84	96.25	57.26
113	97.86	56.50	97.61	56.93	97.36	57.35	97.11	57.78
114	98.73	57.00	98.48	57.43	98.23	57.86	97.97	58.29
115	99.59	57.50	99.34	57.93	99.09	58.37	98.83	58.80
116	100.5	58.00	100.2	58.44	99.95	58.87	99.69	59.31
117	101.3	58.50	101.1	58.94	100.8	59.38	100.6	59.82
118	102.2	59.00	101.9	59.45	101.7	59.89	101.4	60.33
119	103.1	59.50	102.8	59.95	102.5	60.40	102.3	60.84
120	103.9	60.00	103.7	60.45	103.4	60.90	103.1	61.36
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat	Dep.	Lat.
	0'		45'		30'		15'	

59 DEGREES.

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
1	0.86	0.51	0.85	0.52	0.85	0.52	0.85	0.53
2	1.71	1.03	1.71	1.04	1.71	1.04	1.70	1.05
3	2.57	1.55	2.56	1.56	2.56	1.57	2.55	1.58
4	3.43	2.06	3.42	2.08	3.41	2.09	3.40	2.10
5	4.29	2.58	4.27	2.59	4.26	2.61	4.25	2.63
6	5.14	3.09	5.13	3.11	5.12	3.13	5.10	3.16
7	6.00	3.61	5.98	3.63	5.97	3.66	5.95	3.68
8	6.86	4.12	6.84	4.15	6.82	4.18	6.80	4.21
9	7.71	4.64	7.69	4.67	7.67	4.70	7.65	4.74
10	8.57	5.15	8.55	5.19	8.53	5.22	8.50	5.26
11	9.43	5.67	9.40	5.71	9.38	5.75	9.35	5.79
12	10.29	6.18	10.26	6.23	10.23	6.27	10.20	6.31
13	11.14	6.70	11.11	6.74	11.08	6.79	11.05	6.84
14	12.00	7.21	11.97	7.26	11.94	7.32	11.90	7.37
15	12.86	7.73	12.82	7.78	12.79	7.84	12.76	7.89
16	13.71	8.24	13.68	8.30	13.64	8.36	13.61	8.42
17	14.57	8.76	14.53	8.82	14.49	8.88	14.46	8.95
18	15.43	9.27	15.39	9.34	15.35	9.40	15.31	9.47
19	16.29	9.79	16.24	9.86	16.20	9.93	16.16	10.00
20	17.14	10.30	17.10	10.38	17.05	10.45	17.01	10.52
21	18.00	10.82	17.95	10.89	17.91	10.97	17.86	11.05
22	18.86	11.33	18.81	11.41	18.76	11.50	18.71	11.58
23	19.71	11.85	19.66	11.93	19.61	12.02	19.56	12.10
24	20.57	12.36	20.52	12.45	20.46	12.54	20.41	12.63
25	21.43	12.88	21.37	12.97	21.32	13.06	21.26	13.16
26	22.29	13.39	22.23	13.49	22.17	13.59	22.11	13.68
27	23.14	13.91	23.08	14.01	23.02	14.11	22.96	14.21
28	24.00	14.42	23.94	14.53	23.87	14.63	23.81	14.73
29	24.86	14.94	24.79	15.04	24.73	15.15	24.66	15.26
30	25.71	15.45	25.65	15.56	25.58	15.68	25.51	15.79
31	26.57	15.97	26.50	16.08	26.43	16.20	26.36	16.31
32	27.43	16.48	27.36	16.60	27.28	16.72	27.21	16.84
33	28.29	17.00	28.21	17.12	28.14	17.24	28.06	17.37
34	29.14	17.51	29.07	17.64	28.99	17.77	28.91	17.89
35	30.00	18.03	29.92	18.16	29.84	18.29	29.76	18.42
36	30.86	18.54	30.78	18.68	30.70	18.81	30.61	18.94
37	31.72	19.06	31.63	19.19	31.55	19.33	31.46	19.47
38	32.57	19.57	32.49	19.71	32.40	19.85	32.31	20.00
39	33.43	20.09	33.34	20.23	33.25	20.38	33.16	20.52
40	34.29	20.60	34.20	20.75	34.11	20.90	34.01	21.05
41	35.14	21.12	35.05	21.27	34.96	21.42	34.86	21.57
42	36.00	21.63	35.91	21.79	35.81	21.94	35.71	22.10
43	36.86	22.15	36.76	22.31	36.66	22.47	36.57	22.63
44	37.72	22.66	37.62	22.83	37.52	22.99	37.42	23.15
45	38.57	23.18	38.47	23.34	38.37	23.51	38.27	23.68
46	39.43	23.69	39.33	23.86	39.22	24.03	39.12	24.21
47	40.29	24.21	40.18	24.38	40.07	24.56	39.97	24.73
48	41.14	24.72	41.04	24.90	40.93	25.08	40.82	25.26
49	42.00	25.24	41.89	25.42	41.78	25.60	41.67	25.78
50	42.86	25.75	42.75	25.94	42.63	26.12	42.52	26.31
51	43.72	26.27	43.60	26.46	43.48	26.65	43.37	26.84
52	44.57	26.78	44.46	26.98	44.34	27.17	44.22	27.36
53	45.43	27.30	45.31	27.50	45.19	27.69	45.07	27.89
54	46.29	27.81	46.17	28.01	46.04	28.21	45.92	28.42
55	47.14	28.33	47.02	28.53	46.90	28.74	46.77	28.94
56	48.00	28.84	47.88	29.05	47.75	29.26	47.62	29.47
57	48.86	29.36	48.73	29.57	48.60	29.78	48.47	29.99
58	49.72	29.87	49.58	30.09	49.46	30.30	49.32	30.52
59	50.57	30.39	50.44	30.61	50.31	30.83	50.17	31.05
60	51.43	30.90	51.29	31.13	51.16	31.35	51.02	31.57
Dist.	0′ Dep.	0′ Lat.	45′ Dep.	45′ Lat.	30′ Dep.	30′ Lat.	15′ Dep.	15′ Lat.

Dist.	0′		15′		30′		45′	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
61	52.29	31.42	52.15	31.65	52.01	31.87	51.87	32.10
62	53.14	31.93	53.00	32.16	52.86	32.39	52.72	32.63
63	54.00	32.45	53.86	32.68	53.72	32.92	53.57	33.15
64	54.86	32.96	54.71	33.20	54.57	33.44	54.42	33.68
65	55.72	33.48	55.57	33.72	55.42	33.96	55.27	34.20
66	56.57	33.99	56.42	34.24	56.27	34.48	56.12	34.73
67	57.43	34.51	57.28	34.76	57.13	35.01	56.98	35.26
68	58.29	35.02	58.13	35.28	57.98	35.53	57.82	35.78
69	59.14	35.54	58.99	35.80	58.83	36.05	58.67	36.31
70	60.00	36.05	59.84	36.31	59.68	36.57	59.52	36.84
71	60.86	36.57	60.70	36.83	60.54	37.10	60.37	37.36
72	61.72	37.08	61.55	37.35	61.39	37.62	61.23	37.89
73	62.57	37.60	62.41	37.87	62.24	38.14	62.08	38.41
74	63.43	38.11	63.26	38.39	63.10	38.66	62.93	38.94
75	64.29	38.63	64.12	38.91	63.95	39.19	63.78	39.47
76	65.14	39.14	64.97	39.43	64.80	39.71	64.63	39.99
77	66.00	39.66	65.83	39.95	65.65	40.23	65.48	40.52
78	66.86	40.17	66.68	40.46	66.51	40.75	66.33	41.04
79	67.72	40.69	67.54	40.98	67.36	41.28	67.18	41.57
80	68.57	41.20	68.39	41.50	68.21	41.80	68.03	42.10
81	69.43	41.72	69.25	42.02	69.06	42.32	68.88	42.62
82	70.29	42.23	70.10	42.54	69.92	42.84	69.73	43.15
83	71.14	42.75	70.96	43.06	70.77	43.37	70.58	43.68
84	72.00	43.26	71.81	43.58	71.62	43.89	71.43	44.20
85	72.86	43.78	72.67	44.10	72.47	44.41	72.28	44.73
86	73.72	44.29	73.52	44.61	73.33	44.93	73.13	45.25
87	74.57	44.81	74.38	45.13	74.18	45.46	73.98	45.78
88	75.43	45.32	75.23	45.65	75.03	45.98	74.83	46.31
89	76.29	45.84	76.09	46.17	75.89	46.50	75.68	46.83
90	77.15	46.35	76.94	46.69	76.74	47.02	76.53	47.36
91	78.00	46.87	77.80	47.21	77.59	47.55	77.38	47.89
92	78.86	47.38	78.65	47.73	78.44	48.07	78.23	48.41
93	79.72	47.90	79.51	48.25	79.30	48.59	79.08	48.94
94	80.58	48.41	80.36	48.76	80.15	49.11	79.93	49.47
95	81.43	48.93	81.22	49.28	81.00	49.64	80.78	49.99
96	82.29	49.44	82.07	49.80	81.85	50.16	81.63	50.52
97	83.15	49.96	82.93	50.32	82.71	50.68	82.48	51.04
98	84.00	50.47	83.78	50.84	83.56	51.20	83.33	51.57
99	84.86	50.99	84.64	51.36	84.41	51.73	84.18	52.10
100	85.72	51.50	85.49	51.88	85.26	52.25	85.04	52.62
101	86.57	52.02	86.35	52.40	86.12	52.77	85.89	53.15
102	87.43	52.53	87.20	52.91	86.97	53.29	86.74	53.67
103	88.29	53.05	88.06	53.43	87.82	53.82	87.59	54.20
104	89.15	53.56	88.91	53.95	88.67	54.34	88.44	54.73
105	90.00	54.08	89.77	54.47	89.53	54.86	89.29	55.25
106	90.86	54.59	90.62	54.99	90.38	55.38	90.14	55.78
107	91.72	55.11	91.48	55.51	91.23	55.91	90.99	56.30
108	92.57	55.62	92.33	56.03	92.09	56.43	91.84	56.83
109	93.43	56.14	93.19	56.55	92.94	56.95	92.69	57.36
110	94.29	56.65	94.04	57.06	93.79	57.47	93.54	57.88
111	95.15	57.17	94.90	57.58	94.64	58.00	94.39	58.41
112	96.00	57.68	95.75	58.10	95.50	58.52	95.24	58.94
113	96.86	58.20	96.61	58.62	96.35	59.04	96.09	59.46
114	97.72	58.71	97.46	59.14	97.20	59.56	96.94	59.99
115	98.57	59.23	98.31	59.66	98.05	60.09	97.79	60.51
116	99.43	59.74	99.17	60.18	98.91	60.61	98.64	61.04
117	100.3	60.26	100.0	60.70	99.76	61.13	99.49	61.57
118	101.1	60.77	100.9	61.22	100.6	61.65	100.3	62.09
119	102.0	61.29	101.7	61.73	101.5	62.18	101.2	62.62
120	102.9	61.80	102.6	62.25	102.3	62.70	102.0	63.15
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
1	0.85	0.53	0.85	0.53	0.84	0.54	0.84	0.54
2	1.70	1.06	1.69	1.07	1.69	1.07	1.68	1.08
3	2.54	1.59	2.54	1.60	2.53	1.61	2.52	1.62
4	3.39	2.12	3.38	2.13	3.37	2.15	3.36	2.16
5	4.24	2.65	4.23	2.67	4.22	2.69	4.21	2.70
6	5.09	3.18	5.07	3.20	5.06	3.22	5.05	3.25
7	5.94	3.71	5.92	3.74	5.90	3.76	5.89	3.79
8	6.78	4.24	6.77	4.27	6.75	4.30	6.73	4.33
9	7.63	4.77	7.61	4.80	7.59	4.84	7.57	4.87
10	8.48	5.30	8.46	5.34	8.43	5.37	8.41	5.41
11	9.33	5.83	9.30	5.87	9.28	5.91	9.25	5.95
12	10.18	6.36	10.15	6.40	10.12	6.45	10.09	6.49
13	11.02	6.89	10.99	6.94	10.96	6.98	10.93	7.03
14	11.87	7.42	11.84	7.47	11.81	7.52	11.77	7.57
15	12.72	7.95	12.69	8.00	12.65	8.06	12.62	8.11
16	13.57	8.48	13.53	8.54	13.49	8.60	13.46	8.66
17	14.42	9.01	14.38	9.07	14.34	9.13	14.30	9.20
18	15.26	9.54	15.22	9.61	15.18	9.67	15.14	9.74
19	16.11	10.07	16.07	10.14	16.02	10.21	15.98	10.28
20	16.96	10.60	16.91	10.67	16.87	10.75	16.82	10.82
21	17.81	11.13	17.76	11.21	17.71	11.28	17.66	11.36
22	18.66	11.66	18.61	11.74	18.55	11.82	18.50	11.90
23	19.51	12.19	19.45	12.27	19.40	12.36	19.34	12.44
24	20.35	12.72	20.30	12.81	20.24	12.90	20.18	12.98
25	21.20	13.25	21.14	13.34	21.08	13.43	21.03	13.52
26	22.05	13.78	21.99	13.87	21.93	13.97	21.87	14.07
27	22.90	14.31	22.83	14.41	22.77	14.51	22.71	14.61
28	23.75	14.84	23.68	14.94	23.61	15.04	23.55	15.15
29	24.59	15.37	24.53	15.47	24.46	15.58	24.39	15.69
30	25.44	15.90	25.37	16.01	25.30	16.12	25.23	16.23
31	26.29	16.43	26.22	16.54	26.15	16.66	26.07	16.77
32	27.14	16.96	27.06	17.08	26.99	17.19	26.91	17.31
33	27.99	17.49	27.91	17.61	27.83	17.73	27.75	17.85
34	28.83	18.02	28.75	18.14	28.68	18.27	28.60	18.39
35	29.68	18.55	29.60	18.68	29.52	18.81	29.44	18.93
36	30.53	19.08	30.45	19.21	30.36	19.34	30.28	19.48
37	31.38	19.61	31.29	19.74	31.21	19.88	31.12	20.02
38	32.23	20.14	32.14	20.28	32.05	20.42	31.96	20.56
39	33.07	20.67	32.98	20.81	32.89	20.95	32.80	21.10
40	33.92	21.20	33.83	21.34	33.74	21.49	33.64	21.64
41	34.77	21.73	34.67	21.88	34.58	22.03	34.48	22.18
42	35.62	22.26	35.52	22.41	35.42	22.57	35.32	22.72
43	36.47	22.79	36.37	22.95	36.27	23.10	36.16	23.26
44	37.31	23.32	37.21	23.48	37.11	23.64	37.01	23.80
45	38.16	23.85	38.06	24.01	37.95	24.18	37.85	24.34
46	39.01	24.38	38.90	24.55	38.80	24.72	38.69	24.88
47	39.86	24.91	39.75	25.08	39.64	25.25	39.53	25.43
48	40.71	25.44	40.59	25.61	40.48	25.79	40.37	25.97
49	41.55	25.97	41.44	26.15	41.33	26.33	41.21	26.51
50	42.40	26.50	42.29	26.68	42.17	26.87	42.05	27.05
51	43.25	27.03	43.13	27.21	43.01	27.40	42.89	27.59
52	44.10	27.56	43.98	27.75	43.86	27.94	43.73	28.13
53	44.95	28.09	44.82	28.28	44.70	28.48	44.58	28.67
54	45.79	28.62	45.67	28.82	45.54	29.01	45.42	29.21
55	46.64	29.15	46.52	29.35	46.39	29.55	46.26	29.75
56	47.49	29.68	47.36	29.88	47.23	30.09	47.10	30.29
57	48.34	30.21	48.21	30.42	48.07	30.63	47.94	30.84
58	49.19	30.74	49.05	30.95	48.92	31.16	48.78	31.38
59	50.03	31.27	49.90	31.48	49.76	31.70	49.62	31.92
60	50.88	31.80	50.74	32.02	50.60	32.24	50.46	32.46
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
61	51.73	32.33	51.59	32.55	51.45	32.78	51.30	33.00
62	52.58	32.86	52.44	33.08	52.29	33.31	52.14	33.54
63	53.43	33.38	53.28	33.62	53.13	33.85	52.99	34.08
64	54.28	33.91	54.13	34.15	53.98	34.39	53.83	34.62
65	55.12	34.44	54.97	34.68	54.82	34.92	54.67	35.16
66	55.97	34.97	55.82	35.22	55.66	35.46	55.51	35.70
67	56.82	35.50	56.66	35.75	56.51	36.00	56.35	36.25
68	57.67	36.03	57.51	36.29	57.35	36.54	57.19	36.79
69	58.52	36.56	58.36	36.82	58.19	37.07	58.03	37.33
70	59.36	37.09	59.20	37.35	59.04	37.61	59.87	37.87
71	60.21	37.62	60.05	37.89	59.88	38.15	59.71	38.41
72	61.06	38.15	60.89	38.42	60.72	38.69	60.55	38.95
73	61.91	38.68	61.74	38.95	61.57	39.22	61.40	39.49
74	62.76	39.21	62.58	39.49	62.41	39.76	62.24	40.03
75	63.60	39.74	63.43	40.02	63.25	40.30	63.08	49.57
76	64.45	40.27	64.28	40.55	64.10	40.83	63.92	41.11
77	65.30	40.80	65.12	41.09	64.94	41.37	64.76	41.66
78	66.15	41.33	65.97	41.62	65.78	41.91	65.60	42.20
79	67.00	41.86	66.81	42.16	66.63	42.45	66.44	42.74
80	67.84	42.39	67.66	42.69	67.47	42.98	67.28	43.28
81	68.69	42.92	68.50	43.22	68.31	43.52	68.12	43.82
82	69.54	43.45	69.35	43.76	69.16	44.06	69.97	44.36
83	70.39	43.98	70.20	44.29	70.00	44.60	69.81	44.90
84	71.24	44.51	71.04	44.82	70.84	45.13	70.65	45.44
85	72.08	45.04	71.89	45.36	71.69	45.67	71.49	45.98
86	72.93	45.57	72.73	45.89	72.53	46.21	72.33	46.52
87	73.78	46.10	73.58	46.42	73.38	46.75	73.17	47.06
88	74.63	46.63	74.42	46.96	74.22	47.28	74.01	47.61
89	75.48	47.16	75.27	47.49	75.06	47.82	74.85	48.15
90	76.32	47.69	76.12	48.03	75.91	48.36	75.69	48.69
91	77.17	48.22	76.96	48.56	76.75	48.89	76.53	49.23
92	78.02	48.75	77.81	49.09	77.59	49.43	77.38	49.77
93	78.87	49.28	78.65	49.63	78.44	49.97	78.22	50.31
94	79.72	49.81	79.50	50.16	79.28	50.51	79.06	50.85
95	80.56	50.34	80.34	50.69	80.12	51.04	79.90	51.39
96	81.41	50.87	81.19	51.23	80.97	51.58	80.74	51.93
97	82.26	51.40	82.04	51.76	81.81	52.12	81.58	52.47
98	83.11	51.93	82.88	52.29	82.65	52.66	82.42	53.02
99	83.96	52.46	83.73	52.83	83.50	53.19	83.26	53.56
100	84.80	52.99	84.57	53.36	84.34	53.73	84.10	54.10
101	85.65	53.52	85.42	53.90	85.18	54.27	84.94	54.64
102	86.50	54.05	86.26	54.43	86.03	54.80	85.79	55.18
103	87.35	54.58	87.11	54.96	86.87	55.34	86.63	55.72
104	88.20	55.11	87.96	55.50	87.71	55.88	87.47	56.26
105	89.04	55.64	88.80	56.03	88.56	56.42	88.31	56.80
106	89.89	56.17	89.65	56.56	89.40	56.95	89.15	57.34
107	90.74	56.70	90.49	57.10	90.24	57.49	89.99	57.88
108	91.59	57.23	91.34	57.63	91.09	58.03	90.83	58.42
109	92.44	57.76	92.18	58.16	91.93	58.57	91.67	58.97
110	93.29	58.29	93.03	58.70	92.77	59.10	92.51	59.51
111	94.13	58.82	93.88	59.23	93.62	59.64	93.36	60.05
112	94.98	59.35	94.72	59.76	94.46	60.18	94.20	60.59
113	95.83	59.88	95.57	60.30	95.30	60.71	95.04	61.13
114	96.68	60.41	96.41	60.83	96.15	61.25	95.88	61.67
115	97.53	60.94	97.26	61.37	96.99	61.79	96.72	62.21
116	98.37	61.47	98.10	61.90	97.83	62.33	97.56	62.75
117	99.22	62.00	98.95	62.43	98.68	62.86	98.40	63.29
118	100.1	62.53	99.80	62.97	99.52	63.40	99.24	63.83
119	100.9	63.06	100.6	63.50	100.4	63.94	100.1	64.38
120	101.8	63.59	101.5	64.03	101.2	64.48	100.9	64.92
Dist.	0′ Dep.	0′ Lat.	45′ Dep.	45′ Lat.	30′ Dep.	30′ Lat.	15′ Dep.	15′ Lat.

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
1	0.84	0.54	0.84	0.55	0.83	0.55	0.83	0.56
2	1.68	1.09	1.67	1.10	1.67	1.10	1.66	1.11
3	2.52	1.63	2.51	1.64	2.50	1.66	2.49	1.67
4	3.35	2.18	3.35	2.19	3.34	2.21	3.33	2.22
5	4.19	2.72	4.18	2.74	4.17	2.76	4.16	2.78
6	5.03	3.27	5.02	3.29	5.00	3.31	4.99	3.33
7	5.87	3.81	5.85	3.84	5.84	3.86	5.82	3.89
8	6.71	4.36	6.69	4.39	6.67	4.42	6.65	4.44
9	7.55	4.90	7.53	4.93	7.51	4.97	7.48	5.00
10	8.39	5.45	8.36	5.48	8.34	5.52	8.31	5.56
11	9.23	5.99	9.20	6.03	9.17	6.07	9.15	6.11
12	10.06	6.54	10.04	6.58	10.01	6.62	9.98	6.67
13	10.90	7.08	10.87	7.13	10.84	7.18	10.81	7.22
14	11.74	7.62	11.71	7.68	11.67	7.73	11.64	7.78
15	12.58	8.17	12.54	8.22	12.51	8.28	12.47	8.33
16	13.42	8.71	13.38	8.77	13.34	8.83	13.30	8.89
17	14.26	9.26	14.22	9.32	14.18	9.38	14.14	9.44
18	15.10	9.80	15.05	9.87	15.01	9.93	14.97	10.00
19	15.93	10.35	15.89	10.42	15.84	10.49	15.80	10.56
20	16.77	10.89	16.73	10.97	16.68	11.04	16.63	11.11
21	17.61	11.44	17.56	11.51	17.51	11.59	17.46	11.67
22	18.45	11.98	18.40	12.06	18.35	12.14	18.29	12.22
23	19.29	12.53	19.23	12.61	19.18	12.69	19.12	12.78
24	20.13	13.07	20.07	13.16	20.01	13.25	19.96	13.33
25	20.97	13.62	20.91	13.71	20.85	13.80	20.79	13.89
26	21.81	14.16	21.74	14.26	21.68	14.35	21.62	14.44
27	22.64	14.71	22.58	14.80	22.51	14.90	22.45	15.00
28	23.48	15.25	23.42	15.35	23.35	15.45	23.28	15.56
29	24.32	15.79	24.25	15.90	24.18	16.01	24.11	16.11
30	25.16	16.34	25.09	16.45	25.02	16.56	24.94	16.67
31	26.00	16.88	25.92	17.00	25.85	17.11	25.78	17.22
32	26.84	17.43	26.76	17.55	26.68	17.66	26.61	17.78
33	27.68	17.97	27.60	18.09	27.52	18.21	27.44	18.33
34	28.51	18.52	28.43	18.64	28.35	18.77	28.27	18.89
35	29.35	19.06	29.27	19.19	29.19	19.32	29.10	19.44
36	30.19	19.61	30.11	19.74	30.02	19.87	29.93	20.00
37	31.03	20.15	30.94	20.29	30.85	20.42	30.76	20.56
38	31.87	20.70	31.78	20.84	31.69	20.97	31.60	21.11
39	32.71	21.24	32.62	21.38	32.52	21.53	32.43	21.67
40	33.55	21.79	33.45	21.93	33.36	22.08	33.26	22.22
41	34.39	22.33	34.29	22.48	34.19	22.63	34.09	22.78
42	35.22	22.87	35.12	23.03	35.02	23.18	34.92	23.33
43	36.06	23.42	35.96	23.58	35.86	23.73	35.75	23.89
44	36.90	23.96	36.80	24.12	36.69	24.29	36.58	24.45
45	37.74	24.51	37.63	24.67	37.52	24.84	37.42	25.00
46	38.58	25.05	38.47	25.22	38.36	25.39	38.25	25.56
47	39.42	25.60	39.31	25.77	39.19	25.94	39.08	26.11
48	40.26	26.14	40.14	26.32	40.03	26.49	39.91	26.67
49	41.09	26.69	40.98	26.87	40.86	27.04	40.74	27.22
50	41.93	27.23	41.81	27.41	41.69	27.60	41.57	27.78
51	42.77	27.78	42.65	27.96	42.53	28.15	42.40	28.33
52	43.61	28.32	43.49	28.51	43.36	28.70	43.24	28.89
53	44.45	28.87	44.32	29.06	44.20	29.25	44.07	29.45
54	45.29	29.41	45.16	29.61	45.03	29.80	44.90	30.00
55	46.13	29.96	46.00	30.16	45.86	30.36	45.73	30.56
56	46.97	30.50	46.83	30.70	46.70	30.91	46.56	31.11
57	47.80	31.04	47.67	31.25	47.53	31.46	47.39	31.67
58	48.64	31.59	48.50	31.80	48.37	32.01	48.23	32.22
59	49.48	32.13	49.34	32.35	49.20	32.56	49.06	32.78
60	50.32	32.68	50.18	32.90	50.03	33.12	49.89	33.33
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

56 DEGREES.

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
61	51.16	33.22	51.01	33.45	50.87	33.67	50.72	33.89
62	52.00	33.77	51.85	33.99	51.70	34.22	51.55	34.45
63	52.84	34.31	52.69	34.54	52.53	34.77	52.38	35.00
64	53.67	34.86	53.52	35.09	53.37	35.32	53.21	35.56
65	54.51	35.40	54.36	35.64	54.20	35.88	54.05	36.11
66	55.35	35.95	55.19	36.19	55.04	36.43	54.88	36.67
67	56.19	36.49	56.03	36.74	55.87	36.98	55.71	37.22
68	57.03	37.04	56.87	37.28	56.70	37.53	56.54	37.78
69	57.87	37.58	57.70	37.83	57.54	38.08	57.37	38.33
70	58.71	38.12	58.54	38.38	58.37	38.64	58.20	38.89
71	59.55	38.67	59.38	38.93	59.21	39.19	59.03	39.45
72	60.38	39.21	60.21	39.48	60.04	39.74	59.87	40.00
73	61.22	39.76	61.05	40.03	60.87	40.29	60.70	40.56
74	62.06	40.30	61.89	40.57	61.71	40.84	61.53	41.11
75	62.90	40.85	62.72	41.12	62.54	41.40	62.36	41.67
76	63.74	41.39	63.56	41.67	63.38	41.95	63.19	42.22
77	64.58	41.94	64.39	42.22	64.21	42.50	64.02	42.78
78	65.42	42.48	65.23	42.77	65.04	43.05	64.85	43.33
79	66.25	43.03	66.07	43.32	65.88	43.60	65.69	43.89
80	67.09	43.57	66.90	43.86	66.71	44.16	66.52	44.45
81	67.93	44.12	67.74	44.41	67.54	44.71	67.35	45.00
82	68.77	44.66	68.58	44.96	68.38	45.26	68.18	45.56
83	69.61	45.21	69.41	45.51	69.21	45.81	69.01	46.11
84	70.45	45.75	70.25	46.06	70.05	46.36	69.84	46.67
85	71.29	46.29	71.08	46.60	70.88	46.91	70.67	47.22
86	72.13	46.84	71.92	47.15	71.71	47.47	71.51	47.78
87	72.96	47.38	72.76	47.70	72.55	48.02	72.34	48.33
88	73.80	47.93	73.59	48.25	73.38	48.57	73.17	48.89
89	74.64	48.47	74.43	48.80	74.22	49.12	74.00	49.45
90	75.48	49.02	75.27	49.35	75.05	49.67	74.83	50.00
91	76.32	49.56	76.01	49.89	75.88	50.23	75.66	50.56
92	77.16	50.11	76.94	50.44	76.72	50.78	76.50	51.11
93	78.00	50.65	77.77	50.99	77.55	51.33	77.33	51.67
94	78.84	51.20	78.61	51.54	78.39	51.88	78.16	52.22
95	79.67	51.74	79.45	52.09	79.22	52.43	78.99	52.78
96	80.51	52.29	80.28	52.64	80.05	52.99	79.82	53.33
97	81.35	52.83	81.12	53.18	80.89	53.54	80.65	53.89
98	82.19	53.37	81.96	53.73	81.72	54.09	81.48	54.45
99	83.03	53.92	82.79	54.28	82.55	54.64	82.32	55.00
100	83.87	54.46	83.63	54.83	83.39	55.19	83.15	55.56
101	84.71	55.01	84.46	55.38	84.22	55.75	83.98	56.11
102	85.54	55.55	85.30	55.93	85.06	56.30	84.81	56.67
103	86.38	56.10	86.14	56.47	85.89	56.85	85.64	57.22
104	87.22	56.64	86.97	57.02	86.72	57.40	86.47	57.78
105	88.06	57.19	87.81	57.57	87.56	57.95	87.30	58.33
106	88.90	57.73	88.65	58.12	88.39	58.51	88.14	58.89
107	89.74	58.28	89.48	58.67	89.23	59.06	88.97	59.45
108	90.58	58.82	90.32	59.22	90.06	59.61	89.80	60.00
109	91.42	59.37	91.16	59.76	90.89	60.16	90.63	60.56
110	92.25	59.91	91.99	60.31	91.73	60.71	91.46	61.11
111	93.09	60.45	92.83	60.86	92.56	61.26	92.29	61.67
112	93.93	61.00	93.66	61.41	93.40	61.82	93.12	62.22
113	94.77	61.54	94.50	61.96	94.23	62.37	93.96	62.78
114	95.61	62.09	95.34	62.51	95.06	62.92	94.79	63.34
115	96.45	62.63	96.17	63.05	95.90	63.47	95.62	63.89
116	97.29	63.18	97.01	63.60	96.73	64.02	96.45	64.45
117	98.12	63.72	97.85	64.15	97.56	64.58	97.28	65.00
118	98.96	64.27	98.68	64.70	98.40	65.13	98.11	65.56
119	99.80	64.81	99.52	65.25	99.23	65.68	98.94	66.11
120	100.6	65.36	100.4	65.80	100.1	66.23	99.78	66.67
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat	Dep.	Lat
	0′		45′		30′		15′	

56 DEGREES.

Dist.	0′		15′		30′		45′	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
1	0.83	0.56	0.83	0.56	0.82	0.57	0.82	0.57
2	1.66	1.12	1.65	1.13	1.65	1.13	1.64	1.14
3	2.49	1.68	2.48	1.69	2.47	1.70	2.46	1.71
4	3.32	2.24	3.31	2.25	3.30	2.27	3.29	2.28
5	4.15	2.80	4.13	2.81	4.12	2.83	4.11	2.85
6	4.97	3.36	4.96	3.38	4.94	3.40	4.93	3.42
7	5.80	3.91	5.79	3.94	5.77	3.96	5.75	3.99
8	6.63	4.47	6.61	4.50	6.59	4.53	6.57	4.56
9	7.46	5.03	7.44	5.07	7.42	5.10	7.39	5.13
10	8.29	5.59	8.27	5.63	8.24	5.66	8.22	5.70
11	9.12	6.15	9.09	6.19	9.07	6.23	9.04	6.27
12	9.95	6.71	9.92	6.75	9.89	6.80	9.86	6.84
13	10.78	7.27	10.75	7.32	10.71	7.36	10.68	7.41
14	11.61	7.83	11.57	7.88	11.54	7.93	11.50	7.98
15	12.44	8.39	12.40	8.44	12.36	8.50	12.32	8.55
16	13.26	8.95	13.23	9.00	13.19	9.06	13.15	9.12
17	14.09	9.51	14.05	9.57	14.01	9.63	13.97	9.69
18	14.92	10.07	14.88	10.13	14.83	10.20	14.79	10.26
19	15.75	10.62	15.71	10.69	15.66	10.76	15.61	10.83
20	16.58	11.18	16.53	11.26	16.48	11.33	16.43	11.40
21	17.41	11.74	17.36	11.82	17.31	11.89	17.25	11.97
22	18.24	12.30	18.18	12.38	18.13	12.46	18.08	12.54
23	19.07	12.86	19.01	12.94	18.95	13.03	18.90	13.11
24	19.90	13.42	19.84	13.51	19.78	13.59	19.72	13.68
25	20.73	13.98	20.66	14.07	20.60	14.16	20.54	14.25
26	21.55	14.54	21.49	14.63	21.43	14.73	21.36	14.82
27	22.38	15.10	22.32	15.20	22.25	15.29	22.18	15.39
28	23.21	15.66	23.14	15.76	23.08	15.86	23.01	15.96
29	24.04	16.22	23.97	16.32	23.90	16.43	23.83	16.53
30	24.87	16.78	24.80	16.88	24.72	16.99	24.65	17.10
31	25.70	17.33	25.62	17.45	25.55	17.56	25.47	17.67
32	26.53	17.89	26.45	18.01	26.37	18.13	26.29	18.24
33	27.36	18.45	27.28	18.57	27.20	18.69	27.11	18.81
34	28.19	19.01	28.10	19.14	28.02	19.26	27.94	19.38
35	29.02	19.57	28.93	19.70	28.84	19.82	28.76	19.95
36	29.85	20.13	29.76	20.26	29.67	20.39	29.58	20.52
37	30.67	20.69	30.58	20.82	30.49	20.96	30.40	21.09
38	31.50	21.25	31.41	21.39	31.32	21.52	31.22	21.66
39	32.33	21.81	32.24	21.95	32.14	22.09	32.04	22.23
40	33.16	22.37	33.06	22.51	32.97	22.66	32.87	22.80
41	33.99	22.93	33.89	23.07	33.79	23.22	33.69	23.37
42	34.82	23.49	34.72	23.64	34.61	23.79	34.51	23.94
43	35.65	24.05	35.54	24.20	35.44	24.36	35.33	24.51
44	36.48	24.60	36.37	24.76	36.26	24.92	36.15	25.08
45	37.31	25.16	37.20	25.33	37.09	25.49	36.97	25.65
46	38.14	25.72	38.02	25.89	37.91	26.05	37.80	26.22
47	38.96	26.28	38.85	26.45	38.73	26.62	38.62	26.79
48	39.79	26.84	39.68	27.01	39.56	27.19	39.44	27.36
49	40.62	27.40	40.50	27.58	40.38	27.75	40.26	27.93
50	41.45	27.96	41.33	28.14	41.21	28.32	41.08	28.50
51	42.28	28.52	42.16	28.70	42.03	28.89	41.90	29.07
52	43.11	29.08	42.98	29.27	42.85	29.45	42.73	29.64
53	43.94	29.64	43.81	29.83	43.68	30.02	43.55	30.21
54	44.77	30.20	44.64	30.39	44.50	30.59	44.37	30.78
55	45.60	30.76	45.46	30.95	45.33	31.15	45.19	31.35
56	46.43	31.31	46.29	31.52	46.15	31.72	46.01	31.92
57	47.26	31.87	47.12	32.08	46.98	32.29	46.83	32.49
58	48.08	32.43	47.94	32.64	47.80	32.85	47.66	33.06
59	48.91	32.99	48.97	33.21	48.62	33.42	48.48	33.63
60	49.74	33.55	49.60	33.77	49.45	33.98	49.30	34.20
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep.	15′ Lat	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
61	50.57	34.11	50.42	34.33	50.27	34.55	50.12	34.77
62	51.40	34.67	51.25	34.89	51.10	35.12	50.94	35.34
63	52.23	35.23	52.08	35.46	51.92	35.68	51.76	35.91
64	53.06	35.79	52.90	36.02	52.74	36.25	52.59	36.48
65	53.89	36.35	53.73	36.58	53.57	36.82	53.41	37.05
66	54.72	36.91	54.55	37.15	54.39	37.38	54.23	37.62
67	55.55	37.47	55.38	37.71	55.22	37.95	55.05	38.19
68	56.37	38.03	56.21	38.27	56.04	38.52	55.87	38.76
69	57.20	38.58	57.03	38.83	56.86	39.08	56.69	39.33
70	58.03	39.14	57.86	39.40	57.69	39.65	57.52	39.90
71	58.86	39.70	58.69	39.96	58.51	40.21	58.34	40.47
72	59.69	40.26	59.51	40.52	59.34	40.78	59.16	41.04
73	60.52	40.82	60.34	41.08	60.16	41.35	59.98	41.61
74	61.35	41.38	61.17	41.65	60.99	41.91	60.80	42.18
75	62.18	41.94	61.99	42.21	61.81	42.48	61.62	42.75
76	63.01	42.50	62.82	42.77	62.63	43.05	62.45	43.32
77	63.84	43.06	63.65	43.34	63.46	43.61	63.27	43.89
78	64.66	43.62	64.47	43.90	64.28	44.18	64.09	44.46
79	65.49	44.18	65.30	44.46	65.11	44.75	64.91	45.03
80	66.32	44.74	66.13	45.02	65.93	45.31	65.73	45.60
81	67.15	45.29	66.95	45.59	66.75	45.88	66.55	46.17
82	67.98	45.85	67.78	46.15	67.58	46.45	67.37	46.74
83	68.81	46.41	68.61	46.71	68.40	47.01	68.20	47.31
84	69.64	46.97	69.43	47.28	69.23	47.58	69.02	47.88
85	70.47	47.53	70.26	47.84	70.05	48.14	69.84	48.45
86	71.30	48.09	71.09	48.40	70.87	48.71	70.66	49.02
87	72.13	48.65	71.91	48.96	71.70	49.28	71.48	49.59
88	72.96	49.21	72.74	49.53	72.52	49.84	72.30	50.16
89	73.78	49.77	73.57	50.09	73.35	50.41	73.13	50.73
90	74.61	50.33	74.39	50.65	74.17	50.98	73.95	51.30
91	75.44	50.89	75.22	51.22	75.00	51.54	74.77	51.87
92	76.27	51.45	76.05	51.78	75.82	52.11	75.59	52.44
93	77.10	52.00	76.87	52.34	76.64	52.68	76.41	53.01
94	77.93	52.56	77.70	52.90	77.47	53.24	77.23	53.58
95	78.76	53.12	78.53	53.47	78.29	53.81	78.06	54.15
96	79.59	53.68	79.35	54.03	79.12	54.37	78.88	54.72
97	80.42	54.24	80.18	54.59	79.94	54.94	79.70	55.29
98	81.25	54.80	81.01	55.15	80.76	55.51	80.52	55.86
99	82.07	55.36	81.83	55.72	81.59	56.07	81.34	56.43
100	82.90	55.92	82.66	56.28	82.41	56.64	82.16	57.00
101	83.73	56.48	83.49	56.84	83.24	57.21	82.99	57.57
102	84.56	57.04	84.31	57.41	84.06	57.77	83.81	58.14
103	85.39	57.60	85.14	57.97	84.88	58.34	84.63	58.71
104	86.22	58.16	85.97	58.53	85.71	58.91	85.45	59.28
105	87.05	58.72	86.79	59.09	86.53	59.47	86.27	59.85
106	87.98	59.27	87.62	59.66	87.36	60.04	87.09	60.42
107	88.71	59.83	88.45	60.22	88.18	60.61	87.92	60.99
108	89.54	60.39	89.27	60.78	89.01	61.17	88.74	61.56
109	90.37	60.95	90.10	61.35	89.83	61.74	89.56	62.13
110	91.19	61.51	90.92	61.91	90.65	62.30	90.38	62.70
111	92.02	62.07	91.75	62.47	91.48	62.87	91.20	63.27
112	92.85	62.63	92.58	63.03	92.30	63.44	92.02	63.84
113	93.68	63.19	93.40	63.60	93.13	64.00	92.85	64.41
114	94.51	63.75	94.23	64.16	93.95	64.57	93.67	64.98
115	95.34	64.31	95.06	64.72	94.77	65.14	94.49	65.55
116	96.17	64.87	95.88	65.29	95.60	65.70	95.31	66.12
117	97.00	65.43	96.71	65.85	96.42	66.27	96.13	66.69
118	97.83	65.98	97.54	66.41	97.25	66.84	96.95	67.26
119	98.66	66.54	98.36	66.97	98.07	67.40	97.78	67.83
120	99.48	67.10	99.19	67.54	99.90	67.97	98.60	68.40
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

55 DEGREES.

Dist.	0'		15'		30'		45'	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
1	0.82	0.57	0.82	0.58	0.81	0.58	0.81	[illegible]
2	1.64	1.15	1.63	1.15	1.63	1.16	1.62	[illegible]
3	2.46	1.72	2.45	1.73	2.44	1.74	2.43	[illegible]
4	3.28	2.29	3.27	2.31	3.26	2.32	3.25	2.34
5	4.10	2.87	4.08	2.89	4.07	2.90	4.06	2.92
6	4.91	3.44	4.90	3.46	4.88	3.48	4.87	3.51
7	5.73	4.01	5.72	4.04	5.70	4.06	5.68	[illegible]
8	6.55	4.59	6.53	4.62	6.51	4.65	6.49	[illegible]
9	7.37	5.16	7.35	5.19	7.33	5.23	7.30	5.26
10	8.19	5.74	8.17	5.77	8.14	5.81	8.12	5.84
11	9.01	6.31	8.98	6.35	8.96	6.39	8.93	6.43
12	9.83	6.88	9.80	6.93	9.77	6.97	9.74	7.01
13	10.65	7.46	10.62	7.50	10.58	7.55	10.55	7.60
14	11.47	8.03	11.43	8.08	11.40	8.13	11.36	8.18
15	12.29	8.60	12.25	8.66	12.21	8.71	12.17	8.76
16	13.11	9.18	13.07	9.23	13.03	9.29	12.99	9.35
17	13.93	9.75	13.88	9.81	13.84	9.87	13.80	9.93
18	14.74	10.32	14.70	10.39	14.65	10.45	14.61	10.52
19	15.56	10.90	15.52	10.97	15.47	10.03	15.42	11.10
20	16.38	11.47	16.33	11.54	16.28	11.61	16.23	11.69
21	17.20	12.05	17.15	12.12	17.10	12.19	17.04	12.27
22	18.02	12.62	17.97	12.70	17.91	12.78	17.85	12.85
23	18.84	13.19	18.78	13.27	18.72	13.36	18.67	13.44
24	19.66	13.77	19.60	13.85	19.54	13.94	19.48	14.02
25	20.48	14.34	20.42	14.43	20.35	14.52	20.29	14.61
26	21.30	14.91	21.23	15.01	21.17	15.10	21.10	15.19
27	22.12	15.49	22.05	15.58	21.98	15.68	21.91	15.77
28	22.94	16.06	22.87	16.16	22.80	16.26	22.72	16.36
29	23.76	16.63	23.68	16.74	23.61	16.84	23.54	16.94
30	24.57	17.21	24.50	17.31	24.42	17.42	24.35	17.53
31	25.39	17.78	25.32	17.89	25.24	18.00	25.16	18.11
32	26.21	18.35	26.13	18.47	26.05	18.58	25.97	18.70
33	27.03	18.93	26.95	19.05	26.87	19.16	26.78	19.28
34	27.85	19.50	27.77	19.62	27.68	19.74	27.59	19.86
35	28.67	20.08	28.58	20.20	28.49	20.32	28.41	20.45
36	29.49	20.65	29.40	20.78	29.31	20.91	29.22	21.03
37	30.31	21.22	30.22	21.35	30.12	21.49	30.03	21.62
38	31.13	21.80	31.03	21.93	30.94	22.07	30.84	22.20
39	31.95	22.37	31.85	22.51	31.75	22.65	31.65	22.79
40	32.77	22.94	32.67	23.09	32.56	23.23	32.46	23.37
41	33.59	23.52	33.48	23.66	33.38	23.81	33.27	23.95
42	34.40	24.09	34.30	24.24	34.19	24.39	34.09	24.54
43	35.22	24.66	35.12	24.82	35.01	24.97	34.90	25.12
44	36.04	25.24	35.93	25.39	35.82	25.55	35.71	25.71
45	36.86	25.81	36.75	25.97	36.64	26.13	36.52	26.29
46	37.68	26.38	37.57	26.55	37.45	26.71	37.33	26.88
47	38.50	26.96	38.38	27.13	38.26	27.29	38.14	27.46
48	39.32	27.53	39.20	27.70	39.08	27.87	38.96	28.04
49	40.14	28.11	40.02	28.28	39.89	28.45	39.77	28.63
50	40.96	28.68	40.83	28.86	40.71	29.04	40.58	29.21
51	41.78	29.25	41.65	29.43	41.52	29.62	41.39	29.80
52	42.60	29.83	42.47	30.01	42.33	30.20	42.20	30.38
53	43.42	30.40	43.28	30.59	43.15	30.78	43.01	30.97
54	44.23	30.97	44.10	31.17	43.96	31.36	43.83	31.55
55	45.05	31.55	44.92	31.74	44.78	31.94	44.64	32.13
56	45.87	32.12	45.73	32.32	45.59	32.52	45.45	32.72
57	46.69	32.69	46.55	32.90	46.40	33.10	46.26	33.30
58	47.51	33.27	47.37	33.47	47.22	33.68	47.07	33.89
59	48.33	33.84	48.18	34.05	48.03	34.26	47.88	34.47
60	49.15	34.41	49.00	34.63	48.85	34.84	48.69	35.06
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0'		45'		30'		15'	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
61	49.97	34.99	49.82	35.21	49.66	35.42	49.51	35.64
62	50.79	35.56	50.63	35.78	50.48	36.00	50.32	36.22
63	51.61	36.14	51.45	36.36	51.29	36.58	51.13	36.81
64	52.43	36.71	52.27	36.94	52.10	37.16	51.94	37.39
65	53.24	37.28	53.08	37.51	52.92	37.75	52.75	37.98
66	54.06	37.86	53.90	38.09	53.73	38.33	53.56	38.56
67	54.88	38.43	54.71	38.67	54.55	38.91	54.38	39.14
68	55.70	39.00	55.53	39.25	55.36	39.49	55.19	39.73
69	56.52	39.58	56.35	39.82	56.17	40.07	56.00	40.31
70	57.34	40.15	57.16	40.40	56.99	40.65	56.81	40.90
71	58.16	40.72	57.98	40.98	57.80	41.23	57.62	41.48
72	58.98	41.30	58.80	41.55	58.62	41.81	58.43	42.07
73	59.80	41.87	59.61	42.13	59.43	42.39	59.24	42.65
74	60.62	42.44	60.43	42.71	60.24	42.97	60.06	43.23
75	61.44	43.02	61.25	43.29	61.06	43.55	60.87	43.82
76	62.26	43.59	62.06	43.86	61.87	44.13	61.68	44.40
77	63.07	44.17	62.88	44.44	62.69	44.71	62.49	44.99
78	63.89	44.74	63.70	45.02	63.50	45.29	63.30	45.57
79	64.71	45.31	64.51	45.59	64.32	45.88	64.11	46.16
80	65.53	45.89	65.33	46.17	65.13	46.46	64.93	46.74
81	66.35	46.46	66.15	46.75	65.94	47.04	65.74	47.32
82	67.17	47.03	66.96	47.33	66.76	47.62	66.55	47.91
83	67.99	47.61	67.78	47.90	67.57	48.20	67.36	48.49
84	68.81	48.18	68.60	48.48	68.39	48.78	68.17	49.08
85	69.63	48.75	69.41	49.06	69.20	49.36	68.98	49.66
86	70.45	49.33	70.23	49.63	70.01	49.94	69.80	50.25
87	71.27	49.90	71.05	50.21	70.83	50.52	70.61	50.83
88	72.09	50.47	71.86	50.79	71.64	51.10	71.42	51.41
89	72.90	51.05	72.68	51.37	72.46	51.68	72.23	52.00
90	73.72	51.62	73.50	51.94	73.27	52.26	73.04	52.58
91	74.54	52.19	74.31	52.52	74.08	52.84	73.85	53.17
92	75.36	52.77	75.13	53.10	74.90	53.42	74.66	53.75
93	76.18	53.34	75.95	53.67	75.71	54.01	75.48	54.34
94	77.00	53.92	76.76	54.25	76.53	54.59	76.29	54.92
95	77.82	54.49	77.58	54.83	77.34	55.17	77.10	55.50
96	78.64	55.06	78.40	55.41	78.16	55.75	77.91	56.09
97	79.46	55.64	79.21	55.98	78.97	56.33	78.72	56.67
98	80.28	56.21	80.03	56.56	79.78	56.92	79.53	57.26
99	81.10	56.78	80.85	57.14	80.60	57.49	80.35	57.84
100	81.92	57.36	81.66	57.71	81.41	58.07	81.16	58.42
101	82.73	57.93	82.48	58.29	82.23	58.65	81.97	59.01
102	83.55	58.50	83.30	58.87	83.04	59.23	82.78	59.59
103	84.37	59.08	84.11	59.45	83.85	59.81	83.59	60.18
104	85.19	59.65	84.93	60.02	84.67	60.39	84.40	60.76
105	86.01	60.23	85.75	60.60	85.48	60.97	85.22	61.35
106	86.83	60.80	86.56	61.18	86.30	61.55	86.03	61.93
107	87.65	61.37	87.38	61.75	87.11	62.14	86.84	62.51
108	88.47	61.95	88.20	62.33	87.92	62.72	87.65	63.10
109	89.29	62.52	89.01	62.91	88.74	63.30	88.46	63.68
110	90.11	63.09	89.83	63.49	89.55	63.88	89.27	64.27
111	90.93	63.67	90.65	64.06	90.37	64.46	90.08	64.85
112	91.74	64.24	91.46	64.64	91.18	65.04	90.90	65.44
113	92.56	64.81	92.28	65.22	92.00	65.62	91.71	66.02
114	93.38	65.39	93.10	65.79	92.81	66.20	92.52	66.60
115	94.20	65.96	93.91	66.37	93.62	66.78	93.33	67.19
116	95.02	66.53	94.73	66.95	94.44	67.36	94.14	67.77
117	95.84	67.11	95.55	67.53	95.25	67.94	94.95	68.36
118	96.66	67.68	96.36	68.10	96.07	68.52	95.77	68.94
119	97.48	68.26	97.18	68.68	96.88	69.10	96.58	69.53
120	98.30	68.83	98.00	69.26	97.69	69.68	97.39	70.11
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
1	0.86	0.51	0.85	0.52	0.85	0.52	0.85	0.53
2	1.71	1.03	1.71	1.04	1.71	1.04	1.70	1.05
3	2.57	1.55	2.56	1.56	2.56	1.57	2.55	1.58
4	3.43	2.06	3.42	2.08	3.41	2.09	3.40	2.10
5	4.29	2.58	4.27	2.59	4.26	2.61	4.25	2.63
6	5.14	3.09	5.13	3.11	5.12	3.13	5.10	3.16
7	6.00	3.61	5.98	3.63	5.97	3.66	5.95	3.68
8	6.86	4.12	6.84	4.15	6.82	4.18	6.80	4.21
9	7.71	4.64	7.69	4.67	7.67	4.70	7.65	4.74
10	8.57	5.15	8.55	5.19	8.53	5.22	8.50	5.26
11	9.43	5.67	9.40	5.71	9.38	5.75	9.35	5.79
12	10.29	6.18	10.26	6.23	10.23	6.27	10.20	6.31
13	11.14	6.70	11.11	6.74	11.08	6.79	11.05	6.84
14	12.00	7.21	11.97	7.26	11.94	7.32	11.90	7.37
15	12.86	7.73	12.82	7.78	12.79	7.84	12.76	7.89
16	13.71	8.24	13.68	8.30	13.64	8.36	13.61	8.42
17	14.57	8.76	14.53	8.82	14.49	8.88	14.46	8.95
18	15.43	9.27	15.39	9.34	15.35	9.40	15.31	9.47
19	16.29	9.79	16.24	9.86	16.20	9.93	16.16	10.00
20	17.14	10.30	17.10	10.38	17.05	10.45	17.01	10.52
21	18.00	10.82	17.95	10.89	17.91	10.97	17.86	11.05
22	18.86	11.33	18.81	11.41	18.76	11.50	18.71	11.58
23	19.71	11.85	19.66	11.93	19.61	12.02	19.56	12.10
24	20.57	12.36	20.52	12.45	20.46	12.54	20.41	12.63
25	21.43	12.88	21.37	12.97	21.32	13.06	21.26	13.16
26	22.29	13.39	22.23	13.49	22.17	13.59	22.11	13.68
27	23.14	13.91	23.08	14.01	23.02	14.11	22.96	14.21
28	24.00	14.42	23.94	14.53	23.87	14.63	23.81	14.73
29	24.86	14.94	24.79	15.04	24.73	15.15	24.66	15.26
30	25.71	15.45	25.65	15.56	25.58	15.68	25.51	15.79
31	26.57	15.97	26.50	16.08	26.43	16.20	26.36	16.31
32	27.43	16.48	27.36	16.60	27.28	16.72	27.21	16.84
33	28.29	17.00	28.21	17.12	28.14	17.24	28.06	17.37
34	29.14	17.51	29.07	17.64	28.99	17.77	28.91	17.89
35	30.00	18.03	29.92	18.16	29.84	18.29	29.76	18.42
36	30.86	18.54	30.78	18.68	30.70	18.81	30.61	18.94
37	31.72	19.06	31.63	19.19	31.55	19.33	31.46	19.47
38	32.57	19.57	32.49	19.71	32.40	19.85	32.31	20.00
39	33.43	20.09	33.34	20.23	33.25	20.38	33.16	20.52
40	34.29	20.60	34.20	20.75	34.11	20.90	34.01	21.05
41	35.14	21.12	35.05	21.27	34.96	21.42	34.86	21.57
42	36.00	21.63	35.91	21.79	35.81	21.94	35.71	22.10
43	36.86	22.15	36.76	22.31	36.66	22.47	36.57	22.63
44	37.72	22.66	37.62	22.83	37.52	22.99	37.42	23.15
45	38.57	23.18	38.47	23.34	38.37	23.51	38.27	23.68
46	39.43	23.69	39.33	23.86	39.22	24.03	39.12	24.21
47	40.29	24.21	40.18	24.38	40.07	24.56	39.97	24.73
48	41.14	24.72	41.04	24.90	40.93	25.08	40.82	25.26
49	42.00	25.24	41.89	25.42	41.78	25.60	41.67	25.78
50	42.86	25.75	42.75	25.94	42.63	26.12	42.52	26.31
51	43.72	26.27	43.60	26.46	43.48	26.65	43.37	26.84
52	44.57	26.78	44.46	26.98	44.34	27.17	44.22	27.36
53	45.43	27.30	45.31	27.50	45.19	27.69	45.07	27.89
54	46.29	27.81	46.17	28.01	46.04	28.21	45.92	28.42
55	47.14	28.33	47.02	28.53	46.90	28.74	46.77	28.94
56	48.00	28.84	47.88	29.05	47.75	29.26	47.62	29.47
57	48.86	29.36	48.73	29.57	48.60	29.78	48.47	29.99
58	49.72	29.87	49.58	30.09	49.45	30.30	49.32	30.52
59	50.57	30.39	50.44	30.61	50.31	30.83	50.17	31.05
60	51.43	30.90	51.29	31.13	51.16	31.35	51.02	31.57
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
61	52.29	31.42	52.15	31.65	52.01	31.87	51.87	32.10
62	53.14	31.93	53.00	32.16	52.86	32.39	52.72	32.63
63	54.00	32.45	53.86	32.68	53.72	32.92	53.57	33.15
64	54.86	32.96	54.71	33.20	54.57	33.44	54.42	33.68
65	55.72	33.48	55.57	33.72	55.42	33.96	55.27	34.20
66	56.57	33.99	56.42	34.24	56.27	34.48	56.12	34.73
67	57.43	34.51	57.28	34.76	57.13	35.01	56.98	35.26
68	58.29	35.02	58.13	35.28	57.98	35.53	57.82	35.78
69	59.14	35.54	58.99	35.80	58.83	36.05	58.67	36.31
70	60.00	36.05	59.84	36.31	59.68	36.57	59.52	36.84
71	60.86	36.57	60.70	36.83	60.54	37.10	60.37	37.36
72	61.72	37.08	61.55	37.35	61.39	37.62	61.23	37.89
73	62.57	37.60	62.41	37.87	62.24	38.14	62.08	38.41
74	63.43	38.11	63.26	38.39	63.10	38.66	62.93	38.94
75	64.29	38.63	64.12	38.91	63.95	39.19	63.78	39.47
76	65.14	39.14	64.97	39.43	64.80	39.71	64.63	39.99
77	66.00	39.66	65.83	39.95	65.65	40.23	65.48	40.52
78	66.86	40.17	66.68	40.46	66.51	40.75	66.33	41.04
79	67.72	40.69	67.54	40.98	67.36	41.28	67.18	41.57
80	68.57	41.20	68.39	41.50	68.21	41.80	68.03	42.10
81	69.43	41.72	69.25	42.02	69.06	42.32	68.88	42.62
82	70.29	42.23	70.10	42.54	69.92	42.84	69.73	43.15
83	71.14	42.75	70.96	43.06	70.77	43.37	70.58	43.68
84	72.00	43.26	71.81	43.58	71.62	43.89	71.43	44.20
85	72.86	43.78	72.67	44.10	72.47	44.41	72.28	44.73
86	73.72	44.29	73.52	44.61	73.33	44.93	73.13	45.25
87	74.57	44.81	74.38	45.13	74.18	45.46	73.98	45.78
88	75.43	45.32	75.23	45.65	75.03	45.98	74.83	46.31
89	76.29	45.84	76.09	46.17	75.89	46.50	75.68	46.83
90	77.15	46.35	76.94	46.69	76.74	47.02	76.53	47.36
91	78.00	46.87	77.80	47.21	77.59	47.55	77.38	47.89
92	78.86	47.38	78.65	47.73	78.44	48.07	78.23	48.41
93	79.72	47.90	79.51	48.25	79.30	48.59	79.08	48.94
94	80.58	48.41	80.36	48.76	80.15	49.11	79.93	49.47
95	81.43	48.93	81.22	49.28	81.00	49.64	80.78	49.99
96	82.29	49.44	82.07	49.80	81.85	50.16	81.63	50.52
97	83.15	49.96	82.93	50.32	82.71	50.68	82.48	51.04
98	84.00	50.47	83.78	50.84	83.56	51.20	83.33	51.57
99	84.86	50.99	84.64	51.36	84.41	51.73	84.18	52.10
100	85.72	51.50	85.49	51.88	85.26	52.25	85.04	52.62
101	86.57	52.02	86.35	52.40	86.12	52.77	85.89	53.15
102	87.43	52.53	87.20	52.91	86.97	53.29	86.74	53.67
103	88.29	53.05	88.06	53.43	87.82	53.82	87.59	54.20
104	89.15	53.56	88.91	53.95	88.67	54.34	88.44	54.73
105	90.00	54.08	89.77	54.47	89.53	54.86	89.29	55.25
106	90.86	54.59	90.62	54.99	90.38	55.38	90.14	55.78
107	91.72	55.11	91.48	55.51	91.23	55.91	90.99	56.30
108	92.57	55.62	92.33	56.03	92.09	56.43	91.84	56.83
109	93.43	56.14	93.19	56.55	92.94	56.95	92.69	57.36
110	94.29	56.65	94.04	57.06	93.79	57.47	93.54	57.88
111	95.15	57.17	94.90	57.58	94.64	58.00	94.39	58.41
112	96.00	57.68	95.75	58.10	95.50	58.52	95.24	58.94
113	96.86	58.20	96.61	58.62	96.35	59.04	96.09	59.46
114	97.72	58.71	97.46	59.14	97.20	59.56	96.94	59.99
115	98.57	59.23	98.31	59.66	98.05	60.09	97.79	60.51
116	99.43	59.74	99.17	60.18	98.91	60.61	98.64	61.04
117	100.3	60.26	100.0	60.70	99.76	61.13	99.49	61.57
118	101.1	60.77	100.9	61.22	100.6	61.65	100.3	62.09
119	102.0	61.29	101.7	61.73	101.5	62.18	101.2	62.62
120	102.9	61.80	102.6	62.25	102.3	62.70	102.0	63.15
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

58 DEGREES.

Dist.	0′ Lat.	0′ Dep	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
1	0.85	0.53	0.85	0.53	0.84	0.54	0.84	0.54
2	1.70	1.06	1.69	1.07	1.69	1.07	1.68	1.08
3	2.54	1.59	2.54	1.60	2.53	1.61	2.52	1.62
4	3.39	2.12	3.38	2.13	3.37	2.15	3.36	2.16
5	4.24	2.65	4.23	2.67	4.22	2.69	4.21	2.70
6	5.09	3.18	5.07	3.20	5.06	3.22	5.05	3.25
7	5.94	3.71	5.92	3.74	5.90	3.76	5.89	3.79
8	6.78	4.24	6.77	4.27	6.75	4.30	6.73	4.33
9	7.63	4.77	7.61	4.80	7.59	4.84	7.57	4.87
10	8.48	5.30	8.46	5.34	8.43	5.37	8.41	5.41
11	9.33	5.83	9.30	5.87	9.28	5.91	9.25	5.95
12	10.18	6.36	10.15	6.40	10.12	6.45	10.09	6.49
13	11.02	6.89	10.99	6.94	10.96	6.98	10.93	7.03
14	11.87	7.42	11.84	7.47	11.81	7.52	11.77	7.57
15	12.72	7.95	12.69	8.00	12.65	8.06	12.62	8.11
16	13.57	8.48	13.53	8.54	13.49	8.60	13.46	8.66
17	14.42	9.01	14.38	9.07	14.34	9.13	14.30	9.20
18	15.26	9.54	15.22	9.61	15.18	9.67	15.14	9.74
19	16.11	10.07	16.07	10.14	16.02	10.21	15.98	10.28
20	16.96	10.60	16.91	10.67	16.87	10.75	16.82	10.82
21	17.81	11.13	17.76	11.21	17.71	11.28	17.66	11.36
22	18.66	11.66	18.61	11.74	18.55	11.82	18.50	11.90
23	19.51	12.19	19.45	12.27	19.40	12.36	19.34	12.44
24	20.35	12.72	20.30	12.81	20.24	12.90	20.18	12.98
25	21.20	13.25	21.14	13.34	21.08	13.43	21.03	13.52
26	22.05	13.78	21.99	13.87	21.93	13.97	21.87	14.07
27	22.90	14.31	22.83	14.41	22.77	14.51	22.71	14.61
28	23.75	14.84	23.68	14.94	23.61	15.04	23.55	15.15
29	24.59	15.37	24.53	15.47	24.46	15.58	24.39	15.69
30	25.44	15.90	25.37	16.01	25.30	16.12	25.23	16.23
31	26.29	16.43	26.22	16.54	26.15	16.66	26.07	16.77
32	27.14	16.96	27.06	17.08	26.99	17.19	26.91	17.31
33	27.99	17.49	27.91	17.61	27.83	17.73	27.75	17.85
34	28.83	18.02	28.75	18.14	28.68	18.27	28.60	18.39
35	29.68	18.55	29.60	18.68	29.52	18.81	29.44	18.93
36	30.53	19.08	30.45	19.21	30.36	19.34	30.28	19.48
37	31.38	19.61	31.29	19.74	31.21	19.88	31.12	20.02
38	32.23	20.14	32.14	20.28	32.05	20.42	31.96	20.56
39	33.07	20.67	32.98	20.81	32.89	20.95	32.80	21.10
40	33.92	21.20	33.83	21.34	33.74	21.49	33.64	21.64
41	34.77	21.73	34.67	21.88	34.58	22.03	34.48	22.18
42	35.62	22.26	35.52	22.41	35.42	22.57	35.32	22.72
43	36.47	22.79	36.37	22.95	36.27	23.10	36.16	23.26
44	37.31	23.32	37.21	23.48	37.11	23.64	37.01	23.80
45	38.16	23.85	38.06	24.01	37.95	24.18	37.85	24.34
46	39.01	24.38	38.90	24.55	38.80	24.72	38.69	24.88
47	39.86	24.91	39.75	25.08	39.64	25.25	39.53	25.43
48	40.71	25.44	40.59	25.61	40.48	25.79	40.37	25.97
49	41.55	25.97	41.44	26.15	41.33	26.33	41.21	26.51
50	42.40	26.50	42.29	26.68	42.17	26.87	42.05	27.05
51	43.25	27.03	43.13	27.21	43.01	27.40	42.89	27.59
52	44.10	27.56	43.98	27.75	43.86	27.94	43.73	28.13
53	44.95	28.09	44.82	28.28	44.70	28.48	44.58	28.67
54	45.79	28.62	45.67	28.82	45.54	29.01	45.42	29.21
55	46.64	29.15	46.52	29.35	46.39	29.55	46.26	29.75
56	47.49	29.68	47.36	29.88	47.23	30.09	47.10	30.29
57	48.34	30.21	48.21	30.42	48.07	30.63	47.94	30.84
58	49.19	30.74	49.05	30.95	48.92	31.16	48.78	31.38
59	50.03	31.27	49.90	31.48	49.76	31.70	49.62	31.92
60	50.88	31.80	50.74	32.02	50.60	32.24	50.46	32.46
Dist.	Dep.	Lat.	Dep	Lat.	Dep.	Lat	Dep.	Lat.
	0′		45′		30′		15′	

57 DEGREES.

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
61	51.73	32.33	51.59	32.55	51.45	32.78	51.30	33.00
62	52.58	32.86	52.44	33.08	52.29	33.31	52.14	33.54
63	53.43	33.38	53.28	33.62	53.13	33.85	52.99	34.08
64	54.28	33.91	54.13	34.15	53.98	34.39	53.83	34.62
65	55.12	34.44	54.97	34.68	54.82	34.92	54.67	35.16
66	55.97	34.97	55.82	35.22	55.66	35.46	55.51	35.70
67	56.82	35.50	56.66	35.75	56.51	36.00	56.35	36.25
68	57.67	36.03	57.51	36.29	57.35	36.54	57.19	36.79
69	58.52	36.56	58.36	36.82	58.19	37.07	58.03	37.33
70	59.36	37.09	59.20	37.35	59.04	37.61	59.87	37.87
71	60.21	37.62	60.05	37.89	59.88	38.15	59.71	38.41
72	61.06	38.15	60.89	38.42	60.72	38.69	60.55	38.95
73	61.91	38.68	61.74	38.95	61.57	39.22	61.40	39.49
74	62.76	39.21	62.58	39.49	62.41	39.76	62.24	40.03
75	63.60	39.74	63.43	40.02	63.25	40.30	63.08	40.57
76	64.45	40.27	64.28	40.55	64.10	40.83	63.92	41.11
77	65.30	40.80	65.12	41.09	64.94	41.37	64.76	41.66
78	66.15	41.33	65.97	41.62	65.78	41.91	65.60	42.20
79	67.00	41.86	66.81	42.16	66.63	42.45	66.44	42.74
80	67.84	42.39	67.66	42.69	67.47	42.98	67.28	43.28
81	68.69	42.92	68.50	43.22	68.31	43.52	68.12	43.82
82	69.54	43.45	69.35	43.76	69.16	44.06	69.97	44.36
83	70.39	43.98	70.20	44.29	70.00	44.60	69.81	44.90
84	71.24	44.51	71.04	44.82	70.84	45.13	70.65	45.44
85	72.08	45.04	71.89	45.36	71.69	45.67	71.49	45.98
86	72.93	45.57	72.73	45.89	72.53	46.21	72.33	46.52
87	73.78	46.10	73.58	46.42	73.38	46.75	73.17	47.06
88	74.63	46.63	74.42	46.96	74.22	47.28	74.01	47.61
89	75.48	47.16	75.27	47.49	75.06	47.82	74.85	48.15
90	76.32	47.69	76.12	48.03	75.91	48.36	75.69	48.69
91	77.17	48.22	76.96	48.56	76.75	48.89	76.53	49.23
92	78.02	48.75	77.81	49.09	77.59	49.43	77.38	49.77
93	78.87	49.28	78.65	49.63	78.44	49.97	78.22	50.31
94	79.72	49.81	79.50	50.16	79.28	50.51	79.06	50.85
95	80.56	50.24	80.34	50.69	80.12	51.04	79.90	51.39
96	81.41	50.87	81.19	51.23	80.97	51.58	80.74	51.93
97	82.26	51.40	82.04	51.76	81.81	52.12	81.58	52.47
98	83.11	51.93	82.88	52.29	82.65	52.66	82.42	53.02
99	83.96	52.46	83.73	52.83	83.50	53.19	83.26	53.56
100	84.80	52.99	84.57	53.36	84.34	53.73	84.10	54.10
101	85.65	53.52	85.42	53.90	85.18	54.27	84.94	54.64
102	86.50	54.05	86.26	54.43	86.03	54.80	85.79	55.18
103	87.35	54.58	87.11	54.96	86.87	55.34	86.63	55.72
104	88.20	55.11	87.96	55.50	87.71	55.88	87.47	56.26
105	89.04	55.64	88.80	56.03	88.56	56.42	88.31	56.80
106	89.89	56.17	89.65	56.56	89.40	56.95	89.15	57.34
107	90.74	56.70	90.49	57.10	90.24	57.49	89.99	57.88
108	91.59	57.23	91.34	57.63	91.09	58.03	90.83	58.42
109	92.44	57.76	92.18	58.16	91.93	58.57	91.67	58.97
110	93.29	58.29	93.03	58.70	92.77	59.10	92.51	59.51
111	94.13	58.82	93.88	59.23	93.62	59.64	93.36	60.05
112	94.98	59.35	94.72	59.76	94.46	60.18	94.20	60.59
113	95.83	59.88	95.57	60.30	95.30	60.71	95.04	61.13
114	96.68	60.41	96.41	60.83	96.15	61.25	95.88	61.67
115	97.53	60.94	97.26	61.37	96.99	61.79	96.72	62.21
116	98.37	61.47	98.10	61.90	97.83	62.33	97.56	62.75
117	99.22	62.00	98.95	62.43	98.68	62.86	98.40	63.29
118	100.1	62.53	99.80	62.97	99.52	63.40	99.24	63.83
119	100.9	63.06	100.6	63.50	100.4	63.94	100.1	64.38
120	101.8	63.59	101.5	64.03	101.2	64.48	100.9	64.92
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

57 DEGREES.

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
1	0.84	0.54	0.84	0.55	0.83	0.55	0.83	0.56
2	1.68	1.09	1.67	1.10	1.67	1.10	1.66	1.11
3	2.52	1.63	2.51	1.64	2.50	1.66	2.49	1.67
4	3.35	2.18	3.35	2.19	3.34	2.21	3.33	2.22
5	4.19	2.72	4.18	2.74	4.17	2.76	4.16	2.78
6	5.03	3.27	5.02	3.29	5.00	3.31	4.99	3.33
7	5.87	3.81	5.85	3.84	5.84	3.86	5.82	3.89
8	6.71	4.36	6.69	4.39	6.67	4.42	6.65	4.44
9	7.55	4.90	7.53	4.93	7.51	4.97	7.48	5.00
10	8.39	5.45	8.36	5.48	8.34	5.52	8.31	5.56
11	9.23	5.99	9.20	6.03	9.17	6.07	9.15	6.11
12	10.06	6.54	10.04	6.58	10.01	6.62	9.98	6.67
13	10.90	7.08	10.87	7.13	10.84	7.18	10.81	7.22
14	11.74	7.62	11.71	7.68	11.67	7.73	11.64	7.78
15	12.58	8.17	12.54	8.22	12.51	8.28	12.47	8.33
16	13.42	8.71	13.38	8.77	13.34	8.83	13.30	8.89
17	14.26	9.26	14.22	9.32	14.18	9.38	14.14	9.44
18	15.10	9.80	15.05	9.87	15.01	9.93	14.97	10.00
19	15.93	10.35	15.89	10.42	15.84	10.49	15.80	10.56
20	16.77	10.89	16.73	10.97	16.68	11.04	16.63	11.11
21	17.61	11.44	17.56	11.51	17.51	11.59	17.46	11.67
22	18.45	11.98	18.40	12.06	18.35	12.14	18.29	12.22
23	19.29	12.53	19.23	12.61	19.18	12.69	19.12	12.78
24	20.13	13.07	20.07	13.16	20.01	13.25	19.96	13.33
25	20.97	13.62	20.91	13.71	20.85	13.80	20.79	13.89
26	21.81	14.16	21.74	14.26	21.68	14.35	21.62	14.44
27	22.64	14.71	22.58	14.80	22.51	14.90	22.45	15.00
28	23.48	15.25	23.42	15.35	23.35	15.45	23.28	15.56
29	24.32	15.79	24.25	15.90	24.18	16.01	24.11	16.11
30	25.16	16.34	25.09	16.45	25.02	16.56	24.94	16.67
31	26.00	16.88	25.92	17.00	25.85	17.11	25.78	17.22
32	26.84	17.43	26.76	17.55	26.68	17.66	26.61	17.78
33	27.68	17.97	27.60	18.09	27.52	18.21	27.44	18.33
34	28.51	18.52	28.43	18.64	28.35	18.77	28.27	18.89
35	29.35	19.06	29.27	19.19	29.19	19.32	29.10	19.44
36	30.19	19.61	30.11	19.74	30.02	19.87	29.93	20.00
37	31.03	20.15	30.94	20.29	30.85	20.42	30.76	20.56
38	31.87	20.70	31.78	20.84	31.69	20.97	31.60	21.11
39	32.71	21.24	32.62	21.38	32.52	21.53	32.43	21.67
40	33.55	21.79	33.45	21.93	33.36	22.08	33.26	22.22
41	34.39	22.33	34.29	22.48	34.19	22.63	34.09	22.78
42	35.22	22.87	35.12	23.03	35.02	23.18	34.92	23.33
43	36.06	23.42	35.96	23.58	35.86	23.73	35.75	23.89
44	36.90	23.96	36.80	24.12	36.69	24.29	36.58	24.45
45	37.74	24.51	37.63	24.67	37.52	24.84	37.42	25.00
46	38.58	25.05	38.47	25.22	38.36	25.39	38.25	25.56
47	39.42	25.60	39.31	25.77	39.19	25.94	39.08	26.11
48	40.26	26.14	40.14	26.32	40.03	26.49	39.91	26.67
49	41.09	26.69	40.98	26.87	40.86	27.04	40.74	27.22
50	41.93	27.23	41.81	27.41	41.69	27.60	41.57	27.78
51	42.77	27.78	42.65	27.96	42.53	28.15	42.40	28.33
52	43.61	28.32	43.49	28.51	43.36	28.70	43.24	28.89
53	44.45	28.87	44.32	29.06	44.20	29.25	44.07	29.45
54	45.29	29.41	45.16	29.61	45.03	29.80	44.90	30.00
55	46.13	29.96	46.00	30.16	45.86	30.36	45.73	30.56
56	46.97	30.50	46.83	30.70	46.70	30.91	46.56	31.11
57	47.80	31.04	47.67	31.25	47.53	31.46	47.39	31.67
58	48.64	31.59	48.50	31.80	48.37	32.01	48.23	32.22
59	49.48	32.13	49.34	32.35	49.20	32.56	49.06	32.78
60	50.32	32.68	50.18	32.90	50.03	33.12	49.89	33.33
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0' Lat.	0' Dep.	15' Lat.	15' Dep.	30' Lat.	30' Dep.	45' Lat.	45' Dep.
61	51.16	33.22	51.01	33.45	50.87	33.67	50.72	33.89
62	52.00	33.77	51.85	33.99	51.70	34.22	51.55	34.45
63	52.84	34.31	52.69	34.54	52.53	34.77	52.38	35.00
64	53.67	34.86	53.52	35.09	53.37	35.32	53.21	35.56
65	54.51	35.40	54.36	35.64	54.20	35.88	54.05	36.11
66	55.35	35.95	55.19	36.19	55.04	36.43	54.88	36.67
67	56.19	36.49	56.03	36.74	55.87	36.98	55.71	37.22
68	57.03	37.04	56.87	37.28	56.70	37.53	56.54	37.78
69	57.87	37.58	57.70	37.83	57.54	38.08	57.37	38.33
70	58.71	38.12	58.54	38.38	58.37	38.64	58.20	38.89
71	59.55	38.67	59.38	38.93	59.21	39.19	59.03	39.45
72	60.38	39.21	60.21	39.48	60.04	39.74	59.87	40.00
73	61.22	39.76	61.05	40.03	60.87	40.29	60.70	40.56
74	62.06	40.30	61.89	40.57	61.71	40.84	61.53	41.11
75	62.90	40.85	62.72	41.12	62.54	41.40	62.36	41.67
76	63.74	41.39	63.56	41.67	63.38	41.95	63.19	42.22
77	64.58	41.94	64.39	42.22	64.21	42.50	64.02	42.78
78	65.42	42.48	65.23	42.77	65.04	43.05	64.85	43.33
79	66.25	43.03	66.07	43.32	65.88	43.60	65.69	43.89
80	67.09	43.57	66.90	43.86	66.71	44.16	66.52	44.45
81	67.93	44.12	67.74	44.41	67.54	44.71	67.35	45.00
82	68.77	44.66	68.58	44.96	68.38	45.26	68.18	45.56
83	69.61	45.21	69.41	45.51	69.21	45.81	69.01	46.11
84	70.45	45.75	70.25	46.06	70.05	46.36	69.84	46.67
85	71.29	46.29	71.08	46.60	70.88	46.91	70.67	47.22
86	72.13	46.84	71.92	47.15	71.71	47.47	71.51	47.78
87	72.96	47.38	72.76	47.70	72.55	48.02	72.34	48.33
88	73.80	47.93	73.59	48.25	73.38	48.57	73.17	48.89
89	74.64	48.47	74.43	48.80	74.22	49.12	74.00	49.45
90	75.48	49.02	75.27	49.35	75.05	49.67	74.83	50.00
91	76.32	49.56	76.01	49.89	75.88	50.23	75.66	50.56
92	77.16	50.11	76.94	50.44	76.72	50.78	76.50	51.11
93	78.00	50.65	77.77	50.99	77.55	51.33	77.33	51.67
94	78.84	51.20	78.61	51.54	78.39	51.88	78.16	52.22
95	79.67	51.74	79.45	52.09	79.22	52.43	78.99	52.78
96	80.51	52.29	80.28	52.64	80.05	52.99	79.82	53.33
97	81.35	52.83	81.12	53.18	80.89	53.54	80.65	53.89
98	82.19	53.37	81.96	53.73	81.72	54.09	81.48	54.45
99	83.03	53.92	82.79	54.28	82.55	54.64	82.32	55.00
100	83.87	54.46	83.63	54.83	83.39	55.19	83.15	55.56
101	84.71	55.01	84.46	55.38	84.22	55.75	83.98	56.11
102	85.54	55.55	85.30	55.93	85.06	56.30	84.81	56.67
103	86.38	56.10	86.14	56.47	85.89	56.85	85.64	57.22
104	87.22	56.64	86.97	57.02	86.72	57.40	86.47	57.78
105	88.06	57.19	87.81	57.57	87.56	57.95	87.30	58.33
106	88.90	57.73	88.65	58.12	88.39	58.51	88.14	58.89
107	89.74	58.28	89.48	58.67	89.23	59.06	88.97	59.45
108	90.58	58.82	90.32	59.22	90.06	59.61	89.80	60.00
109	91.42	59.37	91.16	59.76	90.89	60.16	90.63	60.56
110	92.25	59.91	91.99	60.31	91.73	60.71	91.46	61.11
111	93.09	60.45	92.83	60.86	92.56	61.26	92.29	61.67
112	93.93	61.00	93.66	61.41	93.40	61.82	93.12	62.22
113	94.77	61.54	94.50	61.96	94.23	62.37	93.96	62.78
114	95.61	62.09	95.34	62.51	95.06	62.92	94.79	63.34
115	96.45	62.63	96.17	63.05	95.90	63.47	95.62	63.89
116	97.29	63.18	97.01	63.60	96.73	64.02	96.45	64.45
117	98.12	63.72	97.85	64.15	97.56	64.58	97.28	65.00
118	98.96	64.27	98.68	64.70	98.40	65.13	98.11	65.56
119	99.80	64.81	99.52	65.25	99.23	65.68	98.94	66.11
120	100.6	65.36	100.4	65.80	100.1	66.23	99.78	66.67
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0'		45'		30'		15'	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
1	0.83	0.56	0.83	0.56	0.82	0.57	0.82	0.57
2	1.66	1.12	1.65	1.13	1.65	1.13	1.64	1.14
3	2.49	1.68	2.48	1.69	2.47	1.70	2.46	1.71
4	3.32	2.24	3.31	2.25	3.30	2.27	3.29	2.28
5	4.15	2.80	4.13	2.81	4.12	2.83	4.11	2.85
6	4.97	3.36	4.96	3.38	4.94	3.40	4.93	3.42
7	5.80	3.91	5.79	3.94	5.77	3.96	5.75	3.99
8	6.63	4.47	6.61	4.50	6.59	4.53	6.57	4.56
9	7.46	5.03	7.44	5.07	7.42	5.10	7.39	5.13
10	8.29	5.59	8.27	5.63	8.24	5.66	8.22	5.70
11	9.12	6.15	9.09	6.19	9.07	6.23	9.04	6.27
12	9.95	6.71	9.92	6.75	9.89	6.80	9.86	6.84
13	10.78	7.27	10.75	7.32	10.71	7.36	10.68	7.41
14	11.61	7.83	11.57	7.88	11.54	7.93	11.50	7.98
15	12.44	8.39	12.40	8.44	12.36	8.50	12.32	8.55
16	13.26	8.95	13.23	9.00	13.19	9.06	13.15	9.12
17	14.09	9.51	14.05	9.57	14.01	9.63	13.97	9.69
18	14.92	10.07	14.88	10.13	14.83	10.20	14.79	10.26
19	15.75	10.62	15.71	10.69	15.66	10.76	15.61	10.83
20	16.58	11.18	16.53	11.26	16.48	11.33	16.43	11.40
21	17.41	11.74	17.36	11.82	17.31	11.89	17.25	11.97
22	18.24	12.30	18.18	12.38	18.13	12.46	18.08	12.54
23	19.07	12.86	19.01	12.94	18.95	13.03	18.90	13.11
24	19.90	13.42	19.84	13.51	19.78	13.59	19.72	13.68
25	20.73	13.98	20.66	14.07	20.60	14.16	20.54	14.25
26	21.55	14.54	21.49	14.63	21.43	14.73	21.36	14.82
27	22.38	15.10	22.32	15.20	22.25	15.29	22.18	15.39
28	23.21	15.66	23.14	15.76	23.08	15.86	23.01	15.96
29	24.04	16.22	23.97	16.32	23.90	16.43	23.83	16.53
30	24.87	16.78	24.80	16.88	24.72	16.99	24.65	17.10
31	25.70	17.33	25.62	17.45	25.55	17.56	25.47	17.67
32	26.53	17.89	26.45	18.01	26.37	18.13	26.29	18.24
33	27.36	18.45	27.28	18.57	27.20	18.69	27.11	18.81
34	28.19	19.01	28.10	19.14	28.02	19.26	27.94	19.38
35	29.02	19.57	28.93	19.70	28.84	19.82	28.76	19.95
36	29.85	20.13	29.76	20.26	29.67	20.39	29.58	20.52
37	30.67	20.69	30.58	20.82	30.49	20.96	30.40	21.09
38	31.50	21.25	31.41	21.39	31.32	21.52	31.22	21.66
39	32.33	21.81	32.24	21.95	32.14	22.09	32.04	22.23
40	33.16	22.37	33.06	22.51	32.97	22.66	32.87	22.80
41	33.99	22.93	33.89	23.07	33.79	23.22	33.69	23.37
42	34.82	23.49	34.72	23.64	34.61	23.79	34.51	23.94
43	35.65	24.05	35.54	24.20	35.44	24.36	35.33	24.51
44	36.48	24.60	36.37	24.76	36.26	24.92	36.15	25.08
45	37.31	25.16	37.20	25.33	37.09	25.49	36.97	25.65
46	38.14	25.72	38.02	25.89	37.91	26.05	37.80	26.22
47	38.96	26.28	38.85	26.45	38.73	26.62	38.62	26.79
48	39.79	26.84	39.68	27.01	39.56	27.19	39.44	27.36
49	40.62	27.40	40.50	27.58	40.38	27.75	40.26	27.93
50	41.45	27.96	41.33	28.14	41.21	28.32	41.08	28.50
51	42.28	28.52	42.16	28.70	42.03	28.89	41.90	29.07
52	43.11	29.08	42.98	29.27	42.85	29.45	42.73	29.64
53	43.94	29.64	43.81	29.83	43.68	30.02	43.55	30.21
54	44.77	30.20	44.64	30.39	44.50	30.59	44.37	30.78
55	45.60	30.76	45.46	30.95	45.33	31.15	45.19	31.35
56	46.43	31.31	46.29	31.52	46.15	31.72	46.01	31.92
57	47.26	31.87	47.12	32.08	46.98	32.29	46.83	32.49
58	48.08	32.43	47.94	32.64	47.80	32.85	47.66	33.06
59	48.91	32.99	48.77	33.21	48.62	33.42	48.48	33.63
60	49.74	33.55	49.60	33.77	49.45	33.98	49.30	34.20
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
61	50.57	34.11	50.42	34.33	50.27	34.55	50.12	34.77
62	51.40	34.67	51.25	34.89	51.10	35.12	50.94	35.34
63	52.23	35.23	52.08	35.46	51.92	35.68	51.76	35.91
64	53.06	35.79	52.90	36.02	52.74	36.25	52.59	36.48
65	53.89	36.35	53.73	36.58	53.57	36.82	53.41	37.05
66	54.72	36.91	54.55	37.15	54.39	37.38	54.23	37.62
67	55.55	37.47	55.38	37.71	55.22	37.95	55.05	38.19
68	56.37	38.03	56.21	38.27	56.04	38.52	55.87	38.76
69	57.20	38.58	57.03	38.83	56.86	39.08	56.69	39.33
70	58.03	39.14	57.86	39.40	57.69	39.65	57.52	39.90
71	58.86	39.70	58.69	39.96	58.51	40.21	58.34	40.47
72	59.69	40.26	59.51	40.52	59.34	40.78	59.16	41.04
73	60.52	40.82	60.34	41.08	60.16	41.35	59.98	41.61
74	61.35	41.38	61.17	41.65	60.99	41.91	60.80	42.18
75	62.18	41.94	61.99	42.21	61.81	42.48	61.62	42.75
76	63.01	42.50	62.82	42.77	62.63	43.05	62.45	43.32
77	63.84	43.06	63.65	43.34	63.46	43.61	63.27	43.89
78	64.66	43.62	64.47	43.90	64.28	44.18	64.09	44.46
79	65.49	44.18	65.30	44.46	65.11	44.75	64.91	45.03
80	66.32	44.74	66.13	45.02	65.93	45.31	65.73	45.60
81	67.15	45.29	66.95	45.59	66.75	45.88	66.55	46.17
82	67.98	45.85	67.78	46.15	67.58	46.45	67.37	46.74
83	68.81	46.41	68.61	46.71	68.40	47.01	68.20	47.31
84	69.64	46.97	69.43	47.28	69.23	47.58	69.02	47.88
85	70.47	47.53	70.26	47.84	70.05	48.14	69.84	48.45
86	71.30	48.09	71.09	48.40	70.87	48.71	70.66	49.02
87	72.13	48.65	71.91	48.96	71.70	49.28	71.48	49.59
88	72.96	49.21	72.74	49.53	72.52	49.84	72.30	50.16
89	73.78	49.77	73.57	50.09	73.35	50.41	73.13	50.73
90	74.61	50.33	74.39	50.65	74.17	50.98	73.95	51.30
91	75.44	50.89	75.22	51.22	75.00	51.54	74.77	51.87
92	76.27	51.45	76.05	51.78	75.82	52.11	75.59	52.44
93	77.10	52.00	76.87	52.34	76.64	52.68	76.41	53.01
94	77.93	52.56	77.70	52.90	77.47	53.24	77.23	53.58
95	78.76	53.12	78.53	53.47	78.29	53.81	78.06	54.15
96	79.59	53.68	79.35	54.03	79.12	54.37	78.88	54.72
97	80.42	54.24	80.18	54.59	79.94	54.94	79.70	55.29
98	81.25	54.80	81.01	55.15	80.76	55.51	80.52	55.86
99	82.07	55.36	81.83	55.72	81.59	56.07	81.34	56.43
100	82.90	55.92	82.66	56.28	82.41	56.64	82.16	57.00
101	83.73	56.48	83.49	56.84	83.24	57.21	82.99	57.57
102	84.56	57.04	84.31	57.41	84.06	57.77	83.81	58.14
103	85.39	57.60	85.14	57.97	84.88	58.34	84.63	58.71
104	86.22	58.16	85.97	58.53	85.71	58.91	85.45	59.28
105	87.05	58.72	86.79	59.09	86.53	59.47	86.27	59.85
106	87.98	59.27	87.62	59.66	87.36	60.04	87.09	60.42
107	88.71	59.83	88.45	60.22	88.18	60.61	87.92	60.99
108	89.54	60.39	89.27	60.78	89.01	61.17	88.74	61.56
109	90.37	60.95	90.10	61.35	89.83	61.74	89.56	62.13
110	91.19	61.51	90.92	61.91	90.65	62.30	90.38	62.70
111	92.02	62.07	91.75	62.47	91.48	62.87	91.20	63.27
112	92.85	62.63	92.58	63.03	92.30	63.44	92.02	63.84
113	93.68	63.19	93.40	63.60	93.13	64.00	92.85	64.41
114	94.51	63.75	94.23	64.16	93.95	64.57	93.67	64.98
115	95.34	64.31	95.06	64.72	94.77	65.14	94.49	65.55
116	96.17	64.87	95.88	65.29	95.60	65.70	95.31	66.12
117	97.00	65.43	96.71	65.85	96.42	66.27	96.13	66.69
118	97.83	65.98	97.54	66.41	97.25	66.84	96.95	67.26
119	98.66	66.54	98.36	66.97	98.07	67.40	97.78	67.83
120	99.48	67.10	99.19	67.54	99.90	67.97	98.60	68.40
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

55 DEGREES

Dist.	0' Lat.	0' Dep.	15' Lat.	15' Dep.	30' Lat.	30' Dep.	45' Lat.	45' Dep.
1	0.82	0.57	0.82	0.58	0.81	0.58	0.81	0.58
2	1.64	1.15	1.63	1.15	1.63	1.16	1.62	1.17
3	2.46	1.72	2.45	1.73	2.44	1.74	2.43	1.75
4	3.28	2.29	3.27	2.31	3.26	2.32	3.25	2.34
5	4.10	2.87	4.08	2.89	4.07	2.90	4.06	2.92
6	4.91	3.44	4.90	3.46	4.88	3.48	4.87	3.51
7	5.73	4.01	5.72	4.04	5.70	4.06	5.68	4.09
8	6.55	4.59	6.53	4.62	6.51	4.65	6.49	4.67
9	7.37	5.16	7.35	5.19	7.33	5.23	7.30	5.26
10	8.19	5.74	8.17	5.77	8.14	5.81	8.12	5.84
11	9.01	6.31	8.98	6.35	8.96	6.39	8.93	6.43
12	9.83	6.88	9.80	6.93	9.77	6.97	9.74	7.01
13	10.65	7.46	10.62	7.50	10.58	7.55	10.55	7.60
14	11.47	8.03	11.43	8.08	11.40	8.13	11.36	8.18
15	12.29	8.60	12.25	8.66	12.21	8.71	12.17	8.76
16	13.11	9.18	13.07	9.23	13.03	9.29	12.99	9.35
17	13.93	9.75	13.88	9.81	13.84	9.87	13.80	9.93
18	14.74	10.32	14.70	10.39	14.65	10.45	14.61	10.52
19	15.56	10.90	15.52	10.97	15.47	10.03	15.42	11.10
20	16.38	11.47	16.33	11.54	16.28	11.61	16.23	11.69
21	17.20	12.05	17.15	12.12	17.10	12.19	17.04	12.27
22	18.02	12.62	17.97	12.70	17.91	12.78	17.85	12.85
23	18.84	13.19	18.78	13.27	18.72	13.36	18.67	13.44
24	19.66	13.77	19.60	13.85	19.54	13.94	19.48	14.02
25	20.48	14.34	20.42	14.43	20.35	14.52	20.29	14.61
26	21.30	14.91	21.23	15.01	21.17	15.10	21.10	15.19
27	22.12	15.49	22.05	15.58	21.98	15.68	21.91	15.77
28	22.94	16.06	22.87	16.16	22.80	16.26	22.72	16.36
29	23.76	16.63	23.68	16.74	23.61	16.84	23.54	16.94
30	24.57	17.21	24.50	17.31	24.42	17.42	24.35	17.53
31	25.39	17.78	25.32	17.89	25.24	18.00	25.16	18.11
32	26.21	18.35	26.13	18.47	26.05	18.58	25.97	18.70
33	27.03	18.93	26.95	19.05	26.87	19.16	26.78	19.28
34	27.85	19.50	27.77	19.62	27.68	19.74	27.59	19.86
35	28.67	20.08	28.58	20.20	28.49	20.32	28.41	20.45
36	29.49	20.65	29.40	20.78	29.31	20.91	29.22	21.03
37	30.31	21.22	30.22	21.35	30.12	21.49	30.03	21.62
38	31.13	21.80	31.03	21.93	30.94	22.07	30.84	22.20
39	31.95	22.37	31.85	22.51	31.75	22.65	31.65	22.79
40	32.77	22.94	32.67	23.09	32.56	23.23	32.46	23.37
41	33.59	23.52	33.48	23.66	33.38	23.81	33.27	23.95
42	34.40	24.09	34.30	24.24	34.19	24.39	34.09	24.54
43	35.22	24.66	35.12	24.82	35.01	24.97	34.90	25.12
44	36.04	25.24	35.93	25.39	35.82	25.55	35.71	25.71
45	36.86	25.81	36.75	25.97	36.64	26.13	36.52	26.29
46	37.68	26.38	37.57	26.55	37.45	26.71	37.33	26.88
47	38.50	26.96	38.38	27.13	38.26	27.29	38.14	27.46
48	39.32	27.53	39.20	27.70	39.08	27.87	38.96	28.04
49	40.14	28.11	40.02	28.28	39.89	28.45	39.77	28.63
50	40.96	28.68	40.83	28.86	40.71	29.04	40.58	29.21
51	41.78	29.25	41.65	29.43	41.52	29.62	41.39	29.80
52	42.60	29.83	42.47	30.01	42.33	30.20	42.20	30.38
53	43.42	30.40	43.28	30.59	43.15	30.78	43.01	30.97
54	44.23	30.97	44.10	31.17	43.96	31.36	43.83	31.55
55	45.05	31.55	44.92	31.74	44.78	31.94	44.64	32.13
56	45.87	32.12	45.73	32.32	45.59	32.52	45.45	32.72
57	46.69	32.69	46.55	32.90	46.40	33.10	46.26	33.30
58	47.51	33.27	47.37	33.47	47.22	33.68	47.07	33.89
59	48.33	33.84	48.18	34.05	48.03	34.26	47.88	34.47
60	49.15	34.41	49.00	34.63	48.85	34.84	48.69	35.06
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0'		45'		30'		15'	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
61	49.97	34.99	49.82	35.21	49.66	35.42	49.51	35.64
62	50.79	35.56	50.63	35.78	50.48	36.00	50.32	36.22
63	51.61	36.14	51.45	36.36	51.29	36.58	51.13	36.81
64	52.43	36.71	52.27	36.94	52.10	37.16	51.94	37.39
65	53.24	37.28	53.08	37.51	52.92	37.75	52.75	37.98
66	54.06	37.86	53.90	38.09	53.73	38.33	53.56	38.56
67	54.88	38.43	54.71	38.67	54.55	38.91	54.38	39.14
68	55.70	39.00	55.53	39.25	55.36	39.49	55.19	39.73
69	56.52	39.58	56.35	39.82	56.17	40.07	56.00	40.31
70	57.34	40.15	57.16	40.40	56.99	40.65	56.81	40.90
71	58.16	40.72	57.98	40.98	57.80	41.23	57.62	41.48
72	58.98	41.30	58.80	41.55	58.62	41.81	58.43	42.07
73	59.80	41.87	59.61	42.13	59.43	42.39	59.24	42.65
74	60.62	42.44	60.43	42.71	60.24	42.97	60.06	43.23
75	61.44	43.02	61.25	43.29	61.06	43.55	60.87	43.82
76	62.26	43.59	62.06	43.86	61.87	44.13	61.68	44.40
77	63.07	44.17	62.88	44.44	62.69	44.71	62.49	44.99
78	63.89	44.74	63.70	45.02	63.50	45.29	63.30	45.57
79	64.71	45.31	64.51	45.59	64.32	45.88	64.11	46.16
80	65.53	45.89	65.33	46.17	65.13	46.46	64.93	46.74
81	66.35	46.46	66.15	46.75	65.94	47.04	65.74	47.32
82	67.17	47.03	66.96	47.33	66.76	47.62	66.55	47.91
83	67.99	47.61	67.78	47.90	67.57	48.20	67.36	48.49
84	68.81	48.18	68.60	48.48	68.39	48.78	68.17	49.08
85	69.63	48.75	69.41	49.06	69.20	49.36	68.98	49.66
86	70.45	49.33	70.23	49.63	70.01	49.94	69.80	50.25
87	71.27	49.90	71.05	50.21	70.83	50.52	70.61	50.83
88	72.09	50.47	71.86	50.79	71.64	51.10	71.42	51.41
89	72.90	51.05	72.68	51.37	72.46	51.68	72.23	52.00
90	73.72	51.62	73.50	51.94	73.27	52.26	73.04	52.58
91	74.54	52.20	74.31	52.52	74.08	52.84	73.85	53.17
92	75.36	52.77	75.13	53.10	74.90	53.42	74.66	53.75
93	76.18	53.34	75.95	53.67	75.71	54.01	75.48	54.34
94	77.00	53.92	76.76	54.25	76.53	54.59	76.29	54.92
95	77.82	54.49	77.58	54.83	77.34	55.17	77.10	55.50
96	78.64	55.06	78.40	55.41	78.16	55.75	77.91	56.09
97	79.46	55.64	79.21	55.98	78.97	56.33	78.72	56.67
98	80.28	56.21	80.03	56.56	79.78	56.92	79.53	57.26
99	81.10	56.78	80.85	57.14	80.60	57.49	80.35	57.84
100	81.92	57.36	81.66	57.71	81.41	58.07	81.16	58.42
101	82.73	57.93	82.48	58.29	82.23	58.65	81.97	59.01
102	83.55	58.50	83.30	58.87	83.04	59.23	82.78	59.59
103	84.37	59.08	84.11	59.45	83.85	59.81	83.59	60.18
104	85.19	59.65	84.93	60.02	84.67	60.39	84.40	60.76
105	86.01	60.23	85.75	60.60	85.48	60.97	85.22	61.35
106	86.83	60.80	86.56	61.18	86.30	61.55	86.03	61.93
107	87.65	61.37	87.38	61.75	87.11	62.14	86.84	62.51
108	88.47	61.95	88.20	62.33	87.92	62.72	87.65	63.10
109	89.29	62.52	89.01	62.91	88.74	63.30	88.46	63.68
110	90.11	63.09	89.83	63.49	89.55	63.88	89.27	64.27
111	90.93	63.67	90.65	64.06	90.37	64.46	90.08	64.85
112	91.74	64.24	91.46	64.64	91.18	65.04	90.90	65.44
113	92.56	64.81	92.28	65.22	92.00	65.62	91.71	66.02
114	93.38	65.39	93.10	65.79	92.81	66.20	92.52	66.60
115	94.20	65.96	93.91	66.37	93.62	66.78	93.33	67.19
116	95.02	66.53	94.73	66.95	94.44	67.36	94.14	67.77
117	95.84	67.11	95.55	67.53	95.25	67.94	94.95	68.36
118	96.66	67.68	96.36	68.10	96.07	68.52	95.77	68.94
119	97.48	68.26	97.18	68.68	96.88	69.10	96.58	69.53
120	98.30	68.83	98.00	69.26	97.69	69.68	97.39	70.11
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
1	0.81	0.59	0.81	0.59	0.80	0.59	0.80	0.60
2	1.62	1.18	1.61	1.18	1.61	1.19	1.60	1.20
3	2.43	1.76	2.42	1.77	2.41	1.78	2.40	1.79
4	3.24	2.35	3.23	2.37	3.22	2.38	3.20	2.39
5	4.05	2.94	4.03	2.96	4.02	2.97	4.01	2.99
6	4.85	3.53	4.84	3.55	4.82	3.57	4.81	3.59
7	5.66	4.11	5.65	4.14	5.63	4.16	5.61	4.19
8	6.47	4.70	6.45	4.73	6.43	4.76	6.41	4.79
9	7.28	5.29	7.26	5.32	7.23	5.35	7.21	5.38
10	8.09	5.88	8.06	5.91	8.04	5.95	8.01	5.98
11	8.90	6.47	8.87	6.50	8.84	6.54	8.81	6.58
12	9.71	7.05	9.68	7.10	9.65	7.14	9.61	7.18
13	10.52	7.64	10.48	7.69	10.45	7.73	10.42	7.78
14	11.33	8.23	11.29	8.28	11.25	8.33	11.22	8.38
15	12.14	8.82	12.10	8.87	12.06	8.92	12.02	8.97
16	12.94	9.40	12.90	9.46	12.86	9.52	12.82	9.57
17	13.75	9.99	13.71	10.05	13.67	10.11	13.62	10.17
18	14.56	10.58	14.52	10.64	14.47	10.71	14.42	10.77
19	15.37	11.17	15.32	11.23	15.27	11.30	15.22	11.37
20	16.18	11.76	16.13	11.83	16.08	11.90	16.03	11.97
21	16.99	12.34	16.94	12.42	16.88	12.49	16.83	12.56
22	17.80	12.93	17.74	13.01	17.68	13.09	17.63	13.16
23	18.61	13.52	18.55	13.60	18.49	13.68	18.43	13.76
24	19.42	14.11	19.35	14.19	19.29	14.28	19.23	14.36
25	20.23	14.69	20.16	14.78	20.10	14.87	20.03	14.96
26	21.03	15.28	20.97	15.37	20.90	15.47	20.83	15.56
27	21.84	15.87	21.77	15.97	21.70	16.06	21.63	16.15
28	22.65	16.46	22.58	16.56	22.51	16.65	22.44	16.75
29	23.46	17.05	23.39	17.15	23.31	17.25	23.24	17.35
30	24.27	17.63	24.19	17.74	24.12	17.84	24.04	17.95
31	25.08	18.22	25.00	18.33	24.92	18.44	24.84	18.55
32	25.89	18.81	25.81	18.92	25.72	19.03	25.64	19.15
33	26.70	19.40	26.61	19.51	26.53	19.63	26.44	19.74
34	27.51	19.98	27.42	20.10	27.33	20.22	27.24	20.34
35	28.32	20.57	28.23	20.70	28.13	20.82	28.04	20.94
36	29.12	21.16	29.03	21.29	28.94	21.41	28.85	21.54
37	29.93	21.75	29.84	21.88	29.74	22.01	29.65	22.14
38	30.74	22.34	30.64	22.47	30.55	22.60	30.45	22.74
39	31.55	22.92	31.45	23.06	31.35	23.20	31.25	23.33
40	32.36	23.51	32.26	23.65	32.15	23.79	32.05	23.93
41	33.17	24.10	33.06	24.24	32.96	24.39	32.85	24.53
42	33.98	24.69	33.87	24.83	33.76	24.98	33.65	25.13
43	34.79	25.27	34.68	25.43	34.57	25.58	34.45	25.73
44	35.60	25.86	35.48	26.02	35.37	26.17	35.26	26.33
45	36.41	26.45	36.29	26.61	36.17	26.77	36.06	26.92
46	37.21	27.04	37.10	27.20	36.98	27.36	36.86	27.52
47	38.02	27.63	37.90	27.79	37.78	27.96	37.66	28.12
48	38.83	28.21	38.71	28.38	38.59	28.55	38.46	28.72
49	39.64	28.80	39.52	28.97	39.39	29.15	39.26	29.32
50	40.45	29.39	40.32	29.57	40.19	29.74	40.06	29.92
51	41.26	29.98	41.13	30.16	41.00	30.34	40.86	30.51
52	42.07	30.56	41.94	30.75	41.80	30.93	41.67	31.11
53	42.88	31.15	42.74	31.34	42.60	31.53	42.47	31.71
54	43.69	31.74	43.55	31.93	43.41	32.12	43.27	32.31
55	44.50	32.33	44.35	32.52	44.21	32.72	44.07	32.91
56	45.30	32.92	45.16	33.11	45.02	33.31	44.87	33.51
57	46.11	33.50	45.97	33.70	45.82	33.90	45.67	34.10
58	46.92	34.09	46.77	34.30	46.62	34.50	46.47	34.70
59	47.73	34.68	47.58	34.89	47.43	35.09	47.27	35.30
60	48.54	35.27	48.39	35.48	48.23	35.69	48.08	35.90
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′		15′		30′		45′	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
61	49.35	35.85	49.19	36.07	49.04	36.28	48.88	36.50
62	50.16	36.44	50.00	36.66	49.84	36.88	49.68	37.10
63	50.97	37.03	50.81	37.25	50.64	37.47	50.48	37.69
64	51.78	37.62	51.61	37.84	51.45	38.07	51.28	38.29
65	52.59	38.21	52.42	38.44	52.25	38.66	52.08	38.89
66	53.40	38.79	53.23	39.03	53.05	39.36	52.88	39.49
67	54.20	39.38	54.03	39.62	53.86	39.85	53.68	40.09
68	55.01	39.97	54.84	40.21	54.66	40.45	54.49	40.69
69	55.82	40.56	55.64	40.80	55.47	41.04	55.29	41.28
70	56.63	41.14	56.45	41.39	56.27	41.64	56.09	41.88
71	57.44	41.73	57.26	41.98	57.07	42.23	56.89	42.48
72	58.25	42.32	58.06	42.57	57.88	42.83	57.69	43.08
73	59.06	42.91	58.87	43.17	58.68	43.42	58.49	43.68
74	59.87	43.50	59.68	43.76	59.49	44.02	59.29	44.28
75	60.68	44.08	60.48	44.35	60.29	44.61	60.09	44.87
76	61.49	44.67	61.29	44.94	61.09	45.21	60.90	45.47
77	62.29	45.26	62.10	45.53	61.90	45.80	61.70	46.07
78	63.10	45.85	62.90	46.12	62.70	46.40	62.50	46.67
79	63.91	46.43	63.71	46.71	63.50	46.99	63.30	47.27
80	64.72	47.02	64.52	47.30	64.31	47.59	64.10	47.87
81	65.53	47.61	65.32	47.90	65.11	48.18	64.90	48.46
82	66.34	48.20	66.13	48.49	65.92	48.78	65.70	49.06
83	67.15	48.79	66.93	49.08	66.72	49.37	66.50	49.66
84	67.96	49.37	67.74	49.67	67.52	49.97	67.31	50.26
85	68.77	49.96	68.55	50.26	68.33	50.56	68.11	50.86
86	69.58	50.55	69.35	50.85	69.13	51.15	68.91	51.46
87	70.38	51.14	70.16	51.44	69.94	51.75	69.71	52.05
88	71.19	51.73	70.97	52.04	70.74	52.34	70.51	52.65
89	72.00	52.31	71.77	52.63	71.54	52.94	71.31	53.25
90	72.81	52.90	72.58	53.22	72.35	53.53	72.11	53.85
91	73.62	53.49	73.39	53.81	73.15	54.13	72.91	54.45
92	74.43	54.08	74.19	54.40	73.95	54.72	73.72	55.05
93	75.24	54.66	75.00	54.99	74.76	55.32	74.52	55.64
94	76.05	55.25	75.81	55.58	75.56	55.91	75.32	56.24
95	76.86	55.84	76.61	56.17	76.37	56.51	76.12	56.84
96	77.67	56.43	77.42	56.77	77.17	57.10	76.92	57.44
97	78.47	57.02	78.23	57.36	77.97	57.70	77.72	58.04
98	79.28	57.60	79.03	57.95	78.78	58.29	78.52	58.64
99	80.09	58.19	79.84	58.54	79.58	58.89	79.32	59.23
100	80.90	58.78	80.64	59.13	80.39	59.48	80.13	59.83
101	81.71	59.37	81.45	59.72	81.19	60.08	80.93	60.43
102	82.52	59.95	82.26	60.31	81.99	60.67	81.73	61.03
103	83.33	60.54	83.06	60.90	82.80	61.27	82.53	61.63
104	84.14	61.13	83.87	61.50	83.60	61.86	83.33	62.23
105	84.95	61.72	84.68	62.09	84.41	62.46	84.13	62.82
106	85.76	62.31	85.48	62.68	85.21	63.05	84.93	63.42
107	86.56	62.89	86.29	63.27	86.01	63.65	85.73	64.02
108	87.37	63.48	87.10	63.86	86.82	64.24	86.54	64.62
109	88.18	64.07	87.90	64.45	87.62	64.84	87.34	65.22
110	88.99	64.66	88.71	65.04	88.42	65.43	88.14	65.82
111	89.80	65.24	89.52	65.64	89.23	66.03	88.94	66.41
112	90.61	65.83	90.32	66.23	90.03	66.62	89.74	67.01
113	91.42	66.42	91.13	66.82	90.84	67.22	90.54	67.61
114	92.23	67.01	91.93	67.41	91.64	67.81	91.34	68.21
115	93.04	67.60	92.74	68.00	92.44	68.40	92.14	68.81
116	93.85	68.18	93.55	68.59	93.25	69.00	92.95	69.41
117	94.65	68.77	94.35	69.18	94.05	69.59	93.75	70.00
118	95.46	69.36	95.16	69.77	94.86	70.19	94.55	70.60
119	96.27	69.95	95.97	70.37	95.66	70.78	95.35	71.20
120	97.08	70.53	96.77	70.96	96.46	71.38	96.15	71.80
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
1	0.80	0.60	0.80	0.61	0.79	0.61	0.79	0.61
2	1.60	1.20	1.59	1.21	1.59	1.22	1.58	1.22
3	2.40	1.81	2.39	1.82	2.38	1.83	2.37	1.84
4	3.19	2.41	3.18	2.42	3.17	2.43	3.16	2.45
5	3.99	3.01	3.98	3.03	3.97	3.04	3.95	3.06
6	4.79	3.61	4.78	3.63	4.76	3.65	4.74	3.67
7	5.59	4.21	5.57	4.24	5.55	4.26	5.53	4.29
8	6.39	4.81	6.37	4.84	6.35	4.87	6.33	4.90
9	7.19	5.42	7.16	5.45	7.14	5.48	7.12	5.51
10	7.99	6.02	7.96	6.05	7.93	6.09	7.91	6.12
11	8.78	6.62	8.76	6.66	8.73	6.70	8.70	6.73
12	9.58	7.22	9.55	7.26	9.52	7.31	9.49	7.35
13	10.38	7.82	10.35	7.87	10.31	7.91	10.28	7.96
14	11.18	8.43	11.14	8.47	11.11	8.52	11.07	8.57
15	11.98	9.03	11.94	9.08	11.90	9.13	11.86	9.18
16	12.78	9.63	12.74	9.68	12.69	9.74	12.65	9.80
17	13.58	10.23	13.53	10.29	13.49	10.35	13.44	10.41
18	14.38	10.83	14.33	10.90	14.28	10.96	14.23	11.02
19	15.17	11.43	15.12	11.50	15.07	11.57	15.02	11.63
20	15.97	12.04	15.92	12.11	15.87	12.18	15.81	12.24
21	16.77	12.64	16.72	12.71	16.66	12.78	16.60	12.86
22	17.57	13.24	17.51	13.32	17.45	13.39	17.40	13.47
23	18.37	13.84	18.31	13.92	18.25	14.00	18.19	14.08
24	19.17	14.44	19.10	14.53	19.04	14.61	18.98	14.69
25	19.97	15.05	19.90	15.13	19.83	15.22	19.77	15.31
26	20.76	15.65	20.70	15.74	20.63	15.83	20.56	15.92
27	21.56	16.25	21.49	16.34	21.42	16.44	21.35	16.53
28	22.36	16.85	22.29	16.95	22.21	17.05	22.14	17.14
29	23.16	17.45	23.08	17.55	23.01	17.65	22.93	17.75
30	23.96	18.05	23.88	18.16	23.80	18.26	23.72	18.37
31	24.76	18.66	24.68	18.76	24.59	18.87	24.51	18.98
32	25.56	19.26	25.47	19.37	25.39	19.48	25.30	19.59
33	26.35	19.86	26.27	19.97	26.18	20.09	26.09	20.20
34	27.15	20.46	27.06	20.58	26.97	20.70	26.88	20.82
35	27.95	21.06	27.86	21.19	27.77	21.31	27.67	21.43
36	28.75	21.67	28.66	21.79	28.56	21.92	28.46	22.04
37	29.55	22.27	29.45	22.40	29.35	22.52	29.26	22.95
38	30.35	22.87	30.25	23.00	30.15	23.13	30.05	23.26
39	31.15	43.47	31.04	23.61	30.94	23.74	30.84	23.88
40	31.95	24.07	31.84	24.21	31.73	24.35	31.63	24.49
41	32.74	24.67	32.64	24.82	32.53	24.96	32.42	25.10
42	33.54	25.28	33.43	25.42	33.32	25.57	33.21	25.71
43	34.34	25.88	34.23	26.03	34.11	26.18	34.00	26.33
44	35.14	26.48	35.02	26.63	34.91	26.79	34.79	26.94
45	35.94	27.08	35.82	27.24	35.70	27.39	35.58	27.55
46	36.74	27.68	36.62	27.84	36.49	28.00	36.37	28.16
47	37.54	28.29	37.41	28.45	37.29	28.61	37.16	28.77
48	38.33	28.89	38.21	29.05	38.08	29.22	37.95	29.39
49	39.13	29.49	39.00	29.66	38.87	29.83	38.74	30.00
50	39.93	30.09	39.80	30.26	39.67	30.44	39.53	30.61
51	40.73	30.69	40.60	30.87	40.46	31.05	40.33	31.22
52	41.53	31.29	41.39	31.48	41.25	31.66	41.12	31.84
53	42.33	31.90	42.19	32.08	42.05	32.26	41.91	32.45
54	43.13	32.50	42.98	32.69	42.84	32.87	42.70	33.06
55	43.93	33.10	43.78	33.29	43.63	33.48	43.49	33.67
56	44.72	33.70	44.58	33.90	44.43	34.09	44.28	34.28
57	45.52	34.30	45.37	34.50	45.22	34.70	45.07	34.90
58	46.32	34.91	46.17	35.11	46.01	35.31	45.86	35.51
59	47.12	35.51	46.96	35.71	46.81	35.92	46.65	36.12
60	47.92	36.11	47.76	36.32	47.60	36.53	47.44	36.73
Dist.	Dep. 0′	Lat. 0′	Dep. 45′	Lat. 45′	Dep. 30′	Lat. 30′	Dep. 15′	Lat. 15′

52 DEGREES.

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
61	48.72	36.71	48.56	36.92	48.39	37.13	48.23	37.35
62	49.52	37.31	49.35	37.53	49.19	37.74	49.02	37.96
63	50.31	37.91	50.15	38.13	49.98	38.35	49.81	38.57
64	51.11	38.52	50.94	38.74	50.77	38.96	50.60	39.18
65	51.91	39.12	51.74	39.34	51.57	39.57	51.39	39.79
66	52.71	39.72	52.54	39.95	52.36	40.18	52.19	40.41
67	53.51	40.32	53.33	40.55	53.15	40.79	52.98	41.02
68	54.31	40.92	54.13	41.16	53.95	41.40	53.77	41.63
69	55.11	41.53	54.92	41.77	54.74	42.00	54.56	42.24
70	55.90	42.13	55.72	42.37	55.53	42.61	55.35	42.86
71	56.70	42.73	56.52	42.98	56.33	43.22	56.14	43.47
72	57.50	43.33	57.31	43.58	57.12	43.83	56.93	44.08
73	58.30	43.93	58.11	44.19	57.91	44.44	57.72	44.69
74	59.10	44.53	58.90	44.79	58.71	45.05	58.51	45.30
75	59.90	45.14	59.70	45.40	59.50	45.66	59.30	45.92
76	60.70	45.74	60.50	46.00	60.29	46.27	60.09	46.53
77	61.49	46.34	61.29	46.61	61.09	46.87	60.88	47.14
78	62.29	46.94	62.09	47.21	61.88	47.48	61.67	47.75
79	63.09	47.54	62.88	47.82	62.67	48.09	62.46	48.37
80	63.89	48.15	63.68	48.42	63.47	48.70	63.26	48.98
81	64.69	48.75	64.48	49.03	64.26	49.31	64.05	49.59
82	65.49	49.35	65.27	49.63	65.05	49.92	64.84	50.20
83	66.29	49.95	65.07	50.24	65.85	50.53	65.63	50.81
84	67.09	50.55	66.86	50.84	66.64	51.14	66.42	51.43
85	67.88	51.15	67.66	51.45	67.43	51.74	67.21	52.04
86	68.68	51.76	68.46	52.06	68.23	52.35	68.00	52.65
87	69.48	52.36	69.25	52.66	69.02	52.96	68.79	53.26
88	70.28	52.96	69.05	53.27	69.82	53.57	69.58	53.88
89	71.08	53.56	70.84	53.87	70.61	54.18	70.37	54.49
90	71.88	54.16	71.64	54.48	71.40	54.79	71.16	55.10
91	72.68	54.77	72.44	55.08	72.20	55.40	71.95	55.71
92	73.47	55.37	73.23	55.69	72.99	56.01	72.74	56.32
93	74.27	55.97	74.03	56.29	73.78	56.61	73.53	56.94
94	75.07	56.57	74.82	56.90	74.58	57.22	74.32	57.55
95	75.87	57.17	75.62	57.50	75.37	57.83	75.12	58.16
96	76.67	57.77	76.42	58.11	76.16	58.44	75.91	58.77
97	77.47	58.38	77.21	58.71	76.96	59.05	76.70	59.39
98	78.27	58.98	78.01	59.32	77.75	59.66	77.49	60.00
99	79.06	59.58	78.80	59.92	78.54	60.27	78.28	60.61
100	79.86	60.18	79.60	60.53	79.34	60.88	79.07	61.22
101	80.66	60.78	80.40	61.13	80.13	61.48	79.86	61.83
102	81.46	61.39	81.19	61.74	80.92	62.09	80.65	62.45
103	82.26	61.99	81.99	62.35	81.72	62.70	81.44	63.06
104	83.06	62.59	82.78	62.95	82.51	63.31	82.23	63.67
105	83.86	63.19	83.58	63.55	83.30	63.92	83.02	64.28
106	84.66	63.79	84.38	64.16	84.10	64.53	83.81	64.89
107	85.45	64.39	85.16	64.77	84.89	65.14	84.60	65.51
108	86.25	65.00	85.97	65.37	85.68	65.75	85.39	66.12
109	87.05	65.60	86.76	65.98	86.48	66.36	86.19	66.73
110	87.85	66.20	87.56	66.58	87.27	66.96	86.98	67.34
111	88.65	66.80	88.36	67.19	88.06	67.57	87.77	67.96
112	89.45	67.40	89.15	67.79	88.86	68.18	88.56	68.57
113	90.25	68.11	89.95	68.40	89.65	68.79	89.35	69.18
114	91.04	68.61	90.74	69.00	90.44	69.40	90.14	69.79
115	91.84	69.21	91.54	69.61	91.24	70.01	90.93	70.40
116	92.64	69.81	91.34	70.21	92.03	70.62	91.72	71.02
117	93.44	70.41	93.13	70.82	92.82	71.23	92.51	71.63
118	94.24	71.01	93.93	71.42	93.62	71.83	93.30	72.24
119	95.04	71.62	94.72	72.03	94.41	72.44	94.09	72.85
120	95.84	72.22	95.52	72.64	95.20	73.05	94.88	73.47
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
1	0.79	0.62	0.79	0.62	0.78	0.62	0.78	0.63
2	1.58	1.23	1.57	1.24	1.57	1.24	1.56	1.25
3	2.36	1.85	2.36	1.86	2.35	1.87	2.34	1.88
4	3.15	2.46	3.14	2.48	3.13	2.49	3.12	2.50
5	3.94	3.08	3.93	3.10	3.91	3.11	3.90	3.13
6	4.73	3.69	4.71	3.71	4.70	3.74	4.68	3.76
7	5.52	4.31	5.50	4.33	5.48	4.36	5.46	4.38
8	6.30	4.93	6.28	4.95	6.26	4.98	6.24	5.01
9	7.09	5.54	7.07	5.57	7.04	5.60	7.02	5.63
10	7.88	6.16	7.85	6.19	7.83	6.23	7.80	6.26
11	8.67	6.77	8.64	6.81	8.61	6.85	8.58	6.89
12	9.46	7.39	9.42	7.43	9.39	7.47	9.36	7.51
13	10.24	8.00	10.21	8.05	10.17	8.09	10.14	8.14
14	11.03	8.62	10.99	8.67	10.96	8.72	10.92	8.76
15	11.82	9.23	11.78	9.29	11.74	9.34	11.70	9.39
16	12.61	9.85	12.57	9.91	12.52	9.96	12.48	10.01
17	13.40	10.47	13.35	10.52	13.30	10.58	13.26	10.64
18	14.18	11.08	14.14	11.14	14.09	11.21	14.04	11.27
19	14.97	11.70	14.92	11.76	14.87	11.83	14.82	11.89
20	15.76	12.31	15.71	12.38	15.65	12.45	15.60	12.52
21	16.55	12.93	16.49	13.00	16.43	13.07	16.38	13.14
22	17.34	13.54	17.28	13.62	17.22	13.70	17.16	13.77
23	18.12	14.16	18.06	14.24	18.00	14.32	17.94	14.40
24	18.91	14.78	18.85	14.86	18.78	14.94	18.72	15.02
25	19.70	15.39	19.63	15.48	19.57	15.56	19.50	15.65
26	20.49	16.01	20.42	16.10	20.35	16.19	20.28	16.27
27	21.28	16.62	21.20	16.72	21.13	16.81	21.06	16.90
28	22.06	17.24	21.99	17.33	21.91	17.43	21.84	17.53
29	22.85	17.85	22.77	17.95	22.70	18.05	22.62	18.15
30	23.64	18.47	23.56	18.57	23.48	18.68	23.40	18.78
31	24.43	19.09	24.34	19.19	24.26	19.30	24.18	19.40
32	25.22	19.70	25.13	19.81	25.04	19.92	24.96	20.03
33	26.00	20.32	25.92	20.43	25.83	20.54	25.74	20.66
34	26.79	20.93	26.70	21.05	26.61	21.17	26.52	21.28
35	27.58	21.55	27.49	21.67	27.39	21.79	27.30	21.91
36	28.37	22.16	28.27	22.29	28.17	22.41	28.08	22.53
37	29.16	22.78	29.06	22.91	28.96	23.03	28.86	23.16
38	29.94	23.40	29.84	23.53	29.74	23.66	29.64	23.79
39	30.73	24.01	30.63	24.14	30.52	24.28	30.42	24.41
40	31.52	24.63	31.41	24.76	31.30	24.90	31.20	25.04
41	32.31	25.24	32.20	25.38	32.09	25.52	31.98	25.66
42	33.10	25.86	32.98	26.00	32.87	26.15	32.76	26.29
43	33.88	26.47	33.77	26.62	33.65	26.77	33.53	26.91
44	34.67	27.09	34.55	27.24	34.43	27.39	34.31	27.54
45	35.46	27.70	35.34	27.86	35.22	28.01	35.09	28.17
46	36.25	28.32	36.12	28.48	36.00	28.64	35.87	28.79
47	37.04	28.94	36.91	29.10	36.78	29.26	36.65	29.42
48	37.82	29.55	37.70	29.72	37.57	29.88	37.43	30.04
49	38.61	30.17	38.48	30.34	38.35	30.50	38.21	30.67
50	39.40	30.78	39.27	30.95	39.13	31.13	38.99	31.30
51	40.19	31.40	40.05	31.57	39.91	31.75	39.77	31.92
52	40.98	32.01	40.84	32.19	40.70	32.37	40.55	32.55
53	41.76	32.63	41.62	32.81	41.48	32.99	41.33	33.17
54	42.55	33.25	42.41	33.43	42.26	33.62	42.11	33.80
55	43.34	33.86	43.19	34.05	43.04	34.24	42.89	34.43
56	44.13	34.48	43.98	34.67	43.83	34.86	43.67	35.05
57	44.92	35.09	44.76	35.29	44.61	35.48	44.45	35.68
58	45.70	35.71	45.55	35.91	45.39	36.11	45.23	36.30
59	46.49	36.32	46.33	36.53	46.17	36.73	46.01	36.93
60	47.28	36.94	47.12	37.15	46.96	37.35	46.79	37.56
Dist.	Dep.	Lat.	Dep	Lat.	Dep.	Lat	Dep	Lat.
	0′		45′		30′		15′	

51 DEGREES.

Dist.	0' Lat.	0' Dep.	15' Lat.	15' Dep.	30' Lat.	30' Dep.	45' Lat.	45' Dep.
61	48.07	37.56	47.90	37.76	47.74	37.97	47.57	38.18
62	48.86	38.17	48.69	38.38	48.52	38.60	48.35	38.81
63	49.64	38.79	49.47	39.00	49.30	39.22	49.13	39.43
64	50.43	39.40	50.26	39.62	50.09	39.84	49.91	40.06
65	51.22	40.02	51.05	40.24	50.87	40.46	50.69	40.68
66	52.01	40.63	51.83	40.86	51.65	41.09	51.47	41.31
67	52.80	41.25	52.62	41.48	52.43	41.71	52.25	41.94
68	53.58	41.86	53.40	42.10	53.22	42.33	53.03	42.56
69	54.37	42.48	54.19	42.72	54.00	42.95	53.81	43.19
70	55.16	43.10	54.97	43.34	54.78	43.58	54.59	43.81
71	55.95	43.71	55.76	43.96	55.57	44.20	55.37	44.44
72	56.74	44.33	56.54	44.57	56.35	44.82	56.15	45.07
73	57.52	44.94	57.33	45.19	57.13	45.44	56.93	45.69
74	58.31	45.56	58.11	45.81	57.91	46.07	57.71	46.32
75	59.10	46.17	58.90	46.43	58.70	46.69	58.49	46.94
76	59.89	46.79	59.68	47.05	59.48	47.31	59.27	47.57
77	60.68	47.41	60.47	47.67	60.26	47.93	60.05	48.20
78	61.46	48.02	61.25	48.29	61.04	48.56	60.83	48.82
79	62.25	48.64	62.04	48.91	61.83	49.18	61.61	49.45
80	63.04	49.25	62.83	49.53	62.61	49.80	62.39	50.07
81	63.83	49.87	63.61	50.15	63.39	50.42	63.17	50.70
82	64.62	50.48	64.40	50.77	64.17	51.05	63.95	51.33
83	65.40	51.10	65.18	51.38	64.96	51.67	64.73	51.95
84	66.19	51.72	65.97	52.00	65.74	52.29	65.51	52.58
85	66.98	52.33	66.75	52.62	66.52	52.91	66.29	53.20
86	67.77	52.95	67.54	53.24	67.30	53.54	67.07	53.83
87	68.56	53.56	68.32	53.86	68.09	54.16	67.85	54.46
88	69.34	54.18	69.11	54.48	68.87	54.78	68.63	55.08
89	70.13	54.79	69.89	55.10	69.65	55.40	69.41	55.71
90	70.92	55.41	70.68	55.72	70.43	56.03	70.19	56.33
91	71.71	56.03	71.46	56.34	71.22	56.65	70.97	56.96
92	72.50	56.64	72.25	56.96	72.00	57.27	71.75	57.58
93	73.28	57.26	73.03	57.58	72.78	57.89	72.53	58.21
94	74.07	57.87	73.82	58.19	73.57	58.52	73.31	58.84
95	74.86	58.49	74.61	58.81	74.35	59.14	74.09	59.46
96	75.65	59.10	75.39	59.43	75.13	59.76	74.87	60.09
97	76.44	59.72	76.18	60.05	75.91	60.38	75.65	60.71
98	77.22	60.33	76.96	60.67	76.70	61.01	76.43	61.34
99	78.01	60.95	77.75	61.29	77.48	61.63	77.21	61.97
100	78.80	61.57	78.53	61.91	78.26	62.25	77.99	62.59
101	79.59	62.18	79.32	62.53	79.04	62.87	78.77	63.22
102	80.38	62.80	80.10	63.15	79.83	63.50	79.55	63.84
103	81.17	63.41	80.89	63.77	80.61	64.12	80.33	64.47
104	81.95	64.02	81.67	64.39	81.39	64.74	81.11	65.10
105	82.74	64.64	82.46	65.00	82.17	65.36	81.89	65.72
106	83.53	65.26	83.24	65.62	82.96	65.99	82.67	66.35
107	84.32	65.88	84.03	66.24	83.74	66.61	83.45	66.97
108	85.11	66.49	84.81	66.86	84.52	67.23	84.23	67.60
109	85.89	67.11	85.60	67.48	85.30	67.85	85.01	68.23
110	86.68	67.72	86.38	68.10	86.09	68.48	85.79	68.85
111	87.47	68.34	87.17	68.72	86.87	69.10	86.57	69.48
112	88.26	68.95	87.96	69.34	87.65	69.72	87.35	70.10
113	89.05	69.57	88.74	69.96	88.43	70.34	88.13	70.73
114	89.83	70.19	89.53	70.58	89.22	70.97	88.91	71.36
115	90.62	70.80	90.31	71.20	90.00	71.59	89.69	71.98
116	91.41	71.42	91.10	71.81	90.78	72.21	90.47	72.61
117	92.20	72.03	91.88	72.43	91.57	72.83	91.25	73.23
118	92.99	72.65	92.67	73.05	92.35	73.46	92.03	73.86
119	93.77	73.26	93.45	73.67	93.13	74.08	92.81	74.48
120	94.56	73.88	94.24	74.29	93.91	74.70	93.59	75.11
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
			45'		30'		15'	

Dist.	0′		15′		30′		45′	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
1	0.78	0.63	0.77	0.63	0.77	0.64	0.77	0.64
2	1.55	1.26	1.55	1.27	1.54	1.27	1.54	1.28
3	2.33	1.89	2.32	1.90	2.31	1.91	2.31	1.92
4	3.11	2.52	3.10	2.53	3.09	2.54	3.08	2.56
5	3.89	3.15	3.87	3.16	3.86	3.18	3.84	3.20
6	4.66	3.78	4.65	3.80	4.63	3.82	4.61	3.84
7	5.44	4.41	5.42	4.43	5.40	4.45	5.38	4.48
8	6.22	5.03	6.20	5.06	6.17	5.09	6.15	5.12
9	6.99	5.66	6.97	5.69	6.94	5.72	6.92	5.75
10	7.77	6.29	7.74	6.33	7.72	6.36	7.69	6.39
11	8.55	6.92	8.52	6.96	8.49	7.00	8.46	7.03
12	9.33	7.55	9.29	7.59	9.26	7.63	9.23	7.67
13	10.10	8.18	10.07	8.23	10.03	8.27	9.99	8.31
14	10.88	8.81	10.84	8.86	10.80	8.91	10.76	8.95
15	11.66	9.44	11.62	9.49	11.57	9.54	11.53	9.59
16	12.43	10.07	12.39	10.12	12.35	10.18	12.30	10.23
17	13.21	10.70	13.16	10.76	13.12	10.81	13.07	10.87
18	13.99	11.33	13.94	11.39	13.89	11.45	13.84	11.51
19	14.77	11.96	14.71	12.02	14.66	12.09	14.61	12.15
20	15.54	12.59	15.49	12.65	15.43	12.72	15.38	12.79
21	16.32	13.22	16.26	13.29	16.20	13.36	16.15	13.43
22	17.10	13.84	17.04	13.92	16.98	13.99	16.91	14.07
23	17.87	14.47	17.81	14.55	17.75	14.63	17.68	14.71
24	18.65	15.10	18.59	15.18	18.52	15.27	18.45	15.35
25	19.43	15.73	19.36	15.82	19.29	15.90	19.22	15.99
26	20.21	16.36	20.13	16.45	20.06	16.54	19.99	16.63
27	20.98	16.99	20.91	17.08	20.83	17.17	20.76	17.26
28	21.76	17.62	21.68	17.72	21.61	17.81	21.53	17.90
29	22.54	18.25	22.46	18.35	22.38	18.45	22.30	18.54
30	23.31	18.88	23.23	18.98	23.15	19.08	23.07	19.18
31	24.09	19.51	24.01	19.61	23.92	19.72	23.83	19.82
32	24.87	20.14	24.78	20.25	24.69	20.35	24.60	20.46
33	25.65	20.77	25.55	20.88	25.46	20.99	25.37	21.10
34	26.42	21.40	26.33	21.51	26.24	21.63	26.14	21.74
35	27.20	22.03	27.10	22.14	27.01	22.26	26.91	22.38
36	27.98	22.66	27.88	22.78	27.78	22.90	27.68	23.02
37	28.75	23.28	28.65	23.41	28.55	23.53	28.45	23.66
38	29.53	23.91	29.43	24.04	29.32	24.17	29.22	24.30
39	30.31	24.54	30.20	24.68	30.09	24.81	29.98	24.94
40	31.09	25.17	30.98	25.31	39.86	25.44	30.75	25.58
41	31.86	25.80	31.75	25.94	31.64	26.08	31.52	26.22
42	32.64	26.43	32.52	26.57	32.41	26.72	32.29	26.86
43	33.42	27.06	33.30	27.21	33.18	27.35	33.06	27.50
44	34.19	27.69	34.07	27.84	33.95	27.99	33.83	28.14
45	34.97	28.32	34.85	28.47	34.72	28.62	34.60	28.77
46	35.75	28.95	35.62	29.10	35.49	29.26	35.37	29.41
47	36.53	29.58	36.40	29.74	36.27	29.90	36.14	30.05
48	37.30	30.21	37.17	30.37	37.04	30.53	36.90	30.69
49	38.08	30.84	37.95	31.00	37.81	31.17	37.67	31.33
50	38.86	31.47	38.72	31.64	38.58	31.80	38.44	31.97
51	39.63	32.10	39.49	32.27	39.35	32.44	39.21	32.61
52	40.41	32.72	40.27	32.90	40.12	33.08	39.98	33.25
53	41.19	33.35	41.04	33.53	40.90	33.71	40.75	33.89
54	41.97	33.98	41.82	34.17	41.67	34.35	41.52	34.53
55	42.74	34.61	42.59	34.80	42.44	34.98	42.29	35.17
56	43.52	35.24	43.37	35.43	43.21	35.62	43.06	35.87
57	44.30	35.87	44.14	36.06	43.98	36.26	43.82	36.41
58	45.07	36.50	44.91	36.70	44.75	36.89	44.59	37.09
59	45.85	37.13	45.69	37.33	45.53	37.53	45.36	37.73
60	46.63	37.76	46.46	37.96	46.30	38.16	46.13	38.37
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
Dist.	0′		45′		30′		15′	

Dist.	0' Lat.	0' Dep.	15' Lat.	15' Dep.	30' Lat.	30' Dep.	45' Lat.	45' Dep.
61	47.41	38.39	47.24	38.60	47.07	38.80	46.90	39.01
62	48.18	39.02	48.01	39.23	47.84	39.44	47.67	39.65
63	48.96	39.65	48.79	39.86	48.61	40.07	48.44	40.28
64	49.74	40.28	49.56	40.49	49.38	40.71	49.21	40.92
65	50.51	40.91	50.34	41.13	50.16	41.35	49.97	41.56
66	51.29	41.54	51.11	41.76	50.93	41.98	50.74	42.20
67	52.07	42.16	51.88	42.39	51.70	42.62	51.51	42.84
68	52.85	42.79	52.66	43.02	52.47	43.25	52.28	43.48
69	53.52	43.42	53.43	43.66	53.24	43.89	53.05	44.12
70	54.40	44.05	54.21	44.29	54.01	44.53	53.82	44.76
71	55.18	44.68	54.98	44.92	54.79	45.16	54.59	45.40
72	55.95	45.31	55.76	45.55	55.56	45.80	55.36	46.04
73	56.73	45.94	56.53	46.19	56.33	46.43	56.13	46.68
74	57.51	46.57	57.31	46.82	57.10	47.07	56.89	47.32
75	58.29	47.20	58.08	47.45	57.87	47.71	57.66	47.96
76	59.06	47.83	58.85	48.09	58.64	48.34	58.43	48.60
77	59.84	48.46	59.63	48.72	59.42	48.98	59.20	49.24
78	60.62	49.09	60.40	49.35	60.19	49.61	59.97	49.88
79	61.39	49.72	61.18	49.98	60.96	50.25	60.74	50.52
80	62.17	50.35	61.95	50.62	61.63	50.89	61.51	51.16
81	62.95	50.97	62.73	51.25	62.50	51.52	62.28	51.79
82	63.73	51.60	63.50	51.88	63.27	52.16	63.04	52.43
83	64.50	52.23	64.27	52.51	64.04	52.79	63.81	53.07
84	65.28	52.86	65.05	53.15	64.82	53.43	64.58	53.71
85	66.06	53.49	65.82	53.78	65.59	54.07	65.35	54.35
86	66.83	54.12	66.60	54.41	66.36	54.70	66.12	54.99
87	67.61	54.75	67.37	55.05	67.13	55.44	66.89	55.63
88	68.39	55.38	68.15	55.68	67.90	55.97	67.66	56.27
89	69.17	56.01	68.92	56.32	68.67	56.61	68.43	56.91
90	69.94	56.64	69.70	56.94	69.45	57.25	69.20	57.55
91	70.72	57.27	70.47	57.58	70.22	57.88	69.96	58.19
92	71.50	57.90	71.24	58.21	70.99	58.52	70.73	58.83
93	72.27	58.53	72.02	58.84	71.76	59.16	71.50	59.47
94	73.05	59.16	72.79	59.47	72.53	59.79	72.27	60.11
95	73.83	59.79	73.57	60.11	73.30	60.43	73.04	60.75
96	74.61	60.41	74.34	60.74	74.08	61.06	73.81	61.39
97	75.38	61.04	75.12	61.37	74.85	61.70	74.58	62.03
98	76.16	61.67	75.89	62.01	75.62	62.34	75.35	62.66
99	76.94	62.30	76.60	62.64	76.39	62.97	76.12	63.30
100	77.71	62.93	77.44	63.27	77.16	63.61	76.88	63.94
101	78.49	63.56	78.21	63.90	77.93	64.24	77.65	64.58
102	79.27	64.19	78.99	64.54	78.71	64.88	78.42	65.22
103	80.05	64.82	79.76	65.17	79.48	65.52	79.19	65.86
104	80.82	65.45	80.54	65.80	80.25	66.15	79.96	66.50
105	81.60	66.08	81.31	66.43	81.02	66.79	80.73	67.14
106	82.38	66.71	82.09	67.07	81.79	67.42	81.50	67.78
107	83.15	67.34	82.80	67.70	82.56	68.06	82.27	68.42
108	83.93	67.97	83.63	68.33	83.34	68.70	83.04	69.06
109	84.71	68.60	84.41	68.96	84.11	69.33	83.80	69.70
110	85.49	69.23	85.18	69.60	84.88	69.97	84.57	70.34
111	86.26	69.85	85.96	70.23	85.65	70.60	85.34	70.98
112	87.04	70.48	86.73	70.86	86.42	71.24	86.11	71.62
113	87.82	71.11	87.51	71.50	87.19	71.88	86.88	72.26
114	88.59	71.74	88.28	72.13	87.97	72.51	87.65	72.90
115	89.37	72.37	89.06	72.76	88.74	73.15	88.42	73.54
116	90.15	73.00	89.83	73.39	89.51	73.79	89.19	74.17
117	90.93	73.63	90.60	74.03	90.28	74.42	89.95	74.81
118	91.70	74.26	91.38	74.66	91.05	75.06	90.72	75.45
119	92.48	74.89	92.15	75.29	91.82	75.69	91.49	76.09
120	93.26	75.52	92.93	75.92	92.59	76.33	92.26	76.73
Dist.	0' Dep.	0' Lat.	45' Dep.	45' Lat.	30' Dep.	30' Lat.	15' Dep.	15' Lat.

50 DEGREES.

Dist.	0′ Lat.	0′ Dep	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
1	0.77	0.64	0.76	0.65	0.76	0.65	0.76	0.65
2	1.53	1.29	1.53	1.29	1.52	1.30	1.52	1.31
3	2.30	1.93	2.29	1.94	2.28	1.95	2.27	1.96
4	3.06	2.57	3.05	2.58	3.04	2.60	3.03	2.61
5	3.83	3.21	3.82	3.23	3.80	3.25	3.79	3.26
6	4.60	3.86	4.58	3.88	4.56	3.90	4.55	3.92
7	5.36	4.50	5.34	4.52	5.32	4.55	5.30	4.57
8	6.13	5.14	6.11	5.17	6.08	5.20	6.06	5.22
9	6.89	5.79	6.87	5.82	6.84	5.84	6.82	5.87
10	7.66	6.43	7.63	6.46	7.60	6.49	7.58	6.53
11	8.43	7.07	8.40	7.11	8.36	7.14	8.33	7.18
12	9.19	7.71	9.19	7.75	9.12	7.70	9.09	7.83
13	9.96	8.36	9.92	8.40	9.89	8.44	9.85	8.49
14	10.72	9.00	10.69	9.05	10.65	9.09	10.61	9.14
15	11.49	9.64	11.45	9.69	11.41	9.74	11.36	9.72
16	12.26	10.28	12.21	10.34	12.17	10.39	12.12	10.44
17	13.02	10.93	12.97	10.98	12.93	11.04	12.88	11.10
18	13.79	11.57	13.74	11.63	13.69	11.69	13.64	11.75
19	14.55	12.21	14.50	12.28	14.45	12.35	14.39	12.40
20	15.32	12.86	15.26	12.92	15.21	12.99	15.15	13.06
21	16.09	13.50	16.03	13.57	15.97	13.64	15.91	13.71
22	16.85	14.14	16.79	14.21	16.73	14.29	16.67	14.36
23	17.62	14.78	17.55	14.86	17.49	14.94	17.42	15.01
24	18.39	15.43	18.32	15.51	18.25	15.59	18.18	15.67
25	19.15	16.07	19.08	16.15	19.01	16.24	18.94	16.32
26	19.92	16.71	19.84	16.80	19.77	16.89	19.70	16.97
27	20.68	17.36	20.61	17.45	20.53	17.54	20.45	17.62
28	21.45	18.00	21.37	18.09	21.29	18.18	21.21	18.28
29	22.22	18.64	22.13	18.74	22.05	18.83	21.97	18.93
30	22.98	19.28	22.90	19.38	22.81	19.48	22.73	19.58
31	23.75	19.93	23.66	20.03	23.57	20.13	23.48	20.24
32	24.51	20.57	24.42	20.68	24.33	20.78	24.24	20.89
33	25.28	21.21	25.19	21.32	25.09	21.43	25.00	21.54
34	26.05	21.85	25.95	21.97	25.85	22.08	25.76	22.19
35	26.81	22.50	26.71	22.61	26.61	22.73	26.51	22.85
36	27.58	23.14	27.48	23.26	27.37	23.38	27.27	23.50
37	28.34	23.78	28.24	23.91	28.12	24.03	28.03	24.15
38	29.11	24.43	29.00	24.55	28.90	24.68	28.79	24.80
39	29.88	25.07	29.77	25.20	29.66	25.33	29.54	25.46
40	30.64	25.71	30.53	25.84	30.42	25.98	30.30	26.11
41	31.41	26.35	31.29	26.49	31.18	26.63	31.06	26.76
42	32.17	27.00	32.06	27.14	31.94	27.28	31.82	27.42
43	32.94	27.64	32.82	27.78	32.70	27.93	32.58	28.07
44	33.71	28.28	33.58	28.43	33.46	28.58	33.33	28.72
45	34.47	28.93	34.35	29.08	34.22	29.23	34.09	29.37
46	35.24	29.57	35.11	29.72	34.98	29.87	34.85	30.03
47	36.00	30.21	35.87	30.37	35.74	30.52	35.61	30.68
48	36.77	30.85	36.64	31.01	36.50	31.17	36.36	31.33
49	37.54	31.50	37.40	31.66	37.26	31.82	37.12	31.99
50	38.30	32.14	38.16	32.31	38.02	32.47	37.88	32.64
51	39.07	32.78	38.92	32.95	38.78	33.12	38.64	33.29
52	39.83	33.42	39.69	33.60	39.54	33.77	39.39	33.94
53	40.60	34.07	40.45	34.24	40.30	34.42	40.15	34.60
54	41.37	34.71	41.21	34.89	41.06	35.07	40.91	35.25
55	42.13	35.35	41.98	35.54	41.82	35.72	41.67	35.90
56	42.90	36.00	42.74	36.18	42.58	36.37	42.45	36.55
57	43.66	36.64	43.50	36.83	43.34	37.02	43.18	37.21
58	44.43	37.28	44.27	37.48	44.10	37.67	43.94	37.86
59	45.20	37.92	45.03	38.12	44.86	38.32	44.70	38.51
60	45.96	38.57	45.79	38.77	45.62	38.97	45.45	39.17
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
61	46.73	39.21	46.56	39.41	46.38	39.62	46.21	39.82
62	47.49	39.85	47.32	40.06	47.15	40.27	46.97	40.47
63	48.26	40.50	48.08	40.71	47.91	40.92	47.73	41.12
64	49.03	41.14	48.85	41.35	48.67	41.56	48.48	41.78
65	49.79	41.78	49.61	42.00	49.43	42.21	49.24	42.43
66	50.56	42.42	50.37	42.64	50.19	42.86	50.00	43.08
67	51.32	43.07	51.14	43.29	50.95	43.51	50.76	43.73
68	52.09	43.71	51.90	43.94	51.71	44.16	51.51	44.39
69	52.86	44.35	52.66	44.58	52.47	44.81	52.27	45.04
70	53.62	45.00	53.43	45.23	53.23	45.46	53.03	45.69
71	54.39	45.64	54.19	45.87	53.99	46.11	53.79	46.35
72	55.16	46.28	54.95	46.52	54.75	46.76	54.54	47.00
73	55.92	46.92	55.72	47.17	55.51	47.41	55.30	47.65
74	56.69	47.57	56.48	47.81	56.27	48.06	56.06	48.30
75	57.45	48.21	57.24	48.46	57.03	48.71	56.82	48.96
76	58.22	48.85	58.01	49.11	57.79	49.36	57.57	49.61
77	58.99	49.49	58.77	49.75	58.55	50.01	58.33	50.26
78	59.75	50.14	59.53	50.40	59.31	50.66	59.09	50.92
79	60.52	50.78	60.30	51.04	60.07	51.31	59.85	51.57
80	61.28	51.42	61.06	51.69	60.83	51.96	60.61	52.22
81	62.05	52.07	61.82	52.34	61.59	52.61	61.36	52.87
82	62.82	52.71	62.59	52.98	62.35	53.25	62.12	53.53
83	63.58	53.35	63.35	53.63	63.11	53.90	62.88	54.18
84	64.35	53.99	64.11	54.27	63.87	54.55	63.64	54.83
85	65.11	54.64	64.87	54.92	64.63	55.20	64.39	55.48
86	65.88	55.28	65.64	55.57	65.39	55.85	65.15	56.14
87	66.65	55.92	66.40	56.21	66.16	56.50	65.91	56.79
88	67.41	56.57	67.16	56.86	66.92	57.15	66.67	57.44
89	68.18	57.21	67.93	57.50	67.68	57.80	67.42	58.10
90	68.94	57.85	68.69	58.15	68.44	58.45	68.18	58.75
91	69.71	58.49	69.45	58.80	69.20	59.10	68.94	59.40
92	70.48	59.14	70.22	59.44	69.96	59.75	69.70	60.05
93	71.24	59.78	70.98	60.09	70.72	60.40	70.45	60.71
94	72.01	60.42	71.74	60.74	71.48	61.05	71.21	61.36
95	72.77	61.06	72.51	61.38	72.24	61.70	71.97	62.01
96	73.54	61.71	73.27	62.03	73.00	62.35	72.73	62.66
97	74.31	62.35	74.03	62.67	73.76	63.00	73.48	63.32
98	75.07	62.99	74.80	63.32	74.52	63.65	74.24	63.97
99	75.84	63.64	75.56	63.97	75.28	64.30	75.00	64.62
100	76.60	64.28	76.32	64.61	76.05	64.94	75.76	65.28
101	77.37	64.92	77.09	65.26	76.80	65.59	76.51	65.93
102	78.14	65.56	77.85	65.90	77.56	66.24	77.27	66.58
103	78.90	66.21	78.61	66.55	78.32	66.89	78.03	67.23
104	79.67	66.85	79.38	67.20	79.08	67.54	78.79	67.89
105	80.43	67.49	80.14	67.84	79.84	68.19	79.54	68.54
106	81.20	68.14	80.90	68.49	80.60	68.84	80.30	69.19
107	81.97	68.78	81.67	69.14	81.36	69.49	81.06	69.85
108	82.73	69.42	82.43	69.78	82.12	70.14	81.82	70.50
109	83.50	70.06	83.19	70.43	82.88	70.79	82.57	71.15
110	84.26	70.71	83.96	71.07	83.64	71.44	83.33	71.80
111	85.03	71.36	84.72	71.72	84.41	72.09	84.09	72.46
112	85.80	71.99	85.48	72.37	85.17	72.74	84.85	73.11
113	86.56	72.64	86.25	73.01	85.93	73.39	85.60	73.76
114	87.33	73.28	87.01	73.66	86.69	74.04	86.36	74.41
115	88.10	73.92	87.77	74.30	87.45	74.69	87.12	75.07
116	88.86	74.56	88.54	74.95	88.21	75.34	87.88	75.72
117	89.63	75.21	89.30	75.60	88.97	75.99	88.64	76.37
118	90.39	75.85	90.06	76.24	89.73	76.63	89.39	77.03
119	91.16	76.49	90.82	76.39	90.49	77.28	90.15	77.68
120	91.93	77.13	91.59	77.53	91.25	77.93	90.91	78.33
Dist.	Dep. 0′	Lat.	Dep. 45′	Lat.	Dep. 30′	Lat.	Dep. 15′	Lat.

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
1	0.75	0.66	0.75	0.66	0.75	0.66	0.75	0.67
2	1.51	1.31	1.50	1.32	1.50	1.33	1.49	1.33
3	2.26	1.97	2.26	1.98	2.25	1.99	2.24	2.00
4	3.02	2.62	3.01	2.64	3.00	2.65	2.98	2.66
5	3.77	3.28	3.76	3.30	3.74	3.31	3.73	3.33
6	4.53	3.94	4.51	3.96	4.49	3.98	4.48	4.00
7	5.28	4.59	5.26	4.62	5.24	4.64	5.22	4.66
8	6.04	5.25	6.01	5.27	5.99	5.30	5.97	5.33
9	6.79	5.90	6.77	5.93	6.74	5.96	6.71	5.99
10	7.55	6.56	7.52	6.59	7.49	6.63	7.46	6.66
11	8.30	7.22	8.27	7.25	8.24	7.29	8.21	7.32
12	9.06	7.87	9.02	7.91	8.99	7.95	8.95	7.99
13	9.81	8.53	9.77	8.57	9.74	8.61	9.70	8.66
14	10.57	9.18	10.53	9.23	10.49	9.28	10.44	9.32
15	11.32	9.84	11.28	9.89	11.23	9.94	11.19	9.99
16	12.08	10.50	12.03	10.55	11.98	10.60	11.94	10.65
17	12.83	11.15	12.78	11.21	12.73	11.26	12.68	11.32
18	13.58	11.81	13.53	11.87	13.48	11.93	13.43	11.99
19	14.34	12.47	14.28	12.53	14.23	12.59	14.18	12.65
20	15.09	13.12	15.04	13.19	14.98	13.25	14.92	13.32
21	15.85	13.78	15.79	13.85	15.73	13.91	15.67	13.98
22	16.60	14.43	16.54	14.51	16.48	14.58	16.41	14.65
23	17.36	15.09	17.29	15.16	17.23	15.24	17.16	15.32
24	18.11	15.75	18.04	15.82	17.97	15.90	17.91	15.98
25	18.87	16.40	18.80	16.48	18.72	16.57	18.65	16.65
26	19.62	17.06	19.55	17.14	19.47	17.23	19.40	17.31
27	20.38	17.71	20.30	17.80	20.22	17.89	20.14	17.98
28	21.13	18.37	21.05	18.46	20.97	18.55	20.89	18.64
29	21.89	19.03	21.80	19.12	21.72	19.22	21.64	19.31
30	22.64	19.68	22.56	19.78	22.47	19.88	22.38	19.98
31	23.40	20.34	23.31	20.44	23.22	20.54	23.13	20.64
32	24.15	20.99	24.06	21.10	23.97	21.20	23.87	21.31
33	24.91	21.65	24.81	21.76	24.72	21.87	24.62	21.97
34	25.66	22.31	25.56	22.42	25.46	22.53	25.37	22.64
35	26.41	22.96	26.31	23.08	26.21	23.19	26.11	23.31
36	27.17	23.62	27.07	23.74	26.96	23.85	26.86	23.97
37	27.92	24.27	27.82	24.40	27.71	24.52	27.60	24.64
38	28.68	24.93	28.57	25.06	28.46	25.18	28.35	25.30
39	29.43	25.59	29.32	25.71	29.21	25.84	29.10	25.97
40	30.19	26.24	30.07	26.37	29.96	26.50	29.84	26.64
41	30.94	26.90	30.83	27.03	30.71	27.17	30.59	27.30
42	31.70	27.55	31.58	27.69	31.46	27.83	31.33	27.97
43	32.45	28.21	32.33	28.35	32.21	28.49	32.08	28.63
44	33.21	28.87	33.08	29.01	32.95	29.16	32.83	29.30
45	33.96	29.52	33.83	29.67	33.70	29.82	33.57	29.97
46	34.72	30.18	34.58	30.33	34.45	30.48	34.32	30.63
47	35.47	30.83	35.34	30.99	35.20	31.14	35.06	31.30
48	36.23	31.49	36.09	31.65	35.95	31.81	35.81	31.96
49	36.98	32.15	36.84	32.31	36.70	32.47	36.56	32.63
50	37.74	32.80	37.59	32.97	37.45	33.13	37.30	33.29
51	38.49	33.46	38.34	33.63	38.20	33.79	38.05	33.96
52	39.24	34.12	39.10	34.29	38.95	34.46	38.79	34.63
53	40.00	34.77	39.85	34.95	39.69	35.12	39.54	35.29
54	40.75	35.43	40.60	35.60	40.44	35.78	40.29	35.96
55	41.51	36.08	41.35	36.26	41.19	36.44	41.03	36.62
56	42.26	36.74	42.10	36.92	41.94	37.11	41.78	37.29
57	43.02	37.40	42.85	37.58	42.69	37.77	42.53	37.96
58	43.77	38.05	43.61	38.24	43.44	38.43	43.27	38.62
59	44.53	38.71	44.36	38.90	44.19	39.09	44.02	39.29
60	45.28	39.36	45.11	39.56	44.99	39.76	44.76	39.95
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist	0′ Lat	0′ Dep.	15′ Lat.	15′ Dep	30′ Lat	30′ Dep.	45′ Lat	45′ Dep
61	46.04	40.02	45.86	40.22	45.69	40.42	45.51	40.62
62	46.79	40.68	46.61	40.88	46.44	41.08	46.26	41.28
63	47.55	41.33	47.37	41.54	47.18	41.75	47.00	41.95
64	48.30	41.99	48.12	42.20	47.93	42.41	47.75	42.62
65	49.06	42.64	48.87	42.86	48.68	43.07	48.49	43.28
66	49.81	43.30	49.62	43.52	49.43	43.73	49.24	43.95
67	50.57	43.96	50.37	44.18	50.18	44.40	49.99	44.61
68	51.32	44.61	51.12	44.84	50.93	45.06	50.73	45.28
69	52.07	45.27	51.88	45.49	51.68	45.72	51.48	45.95
70	52.83	45.92	52.63	46.15	52.43	46.38	52.22	46.61
71	53.58	46.58	53.38	46.81	53.18	47.05	52.97	47.28
72	54.34	47.24	54.13	47.47	53.92	47.71	53.72	47.94
73	55.09	47.89	54.88	48.13	54.67	48.37	54.46	48.61
74	55.85	48.55	55.64	48.79	55.42	49.03	55.21	49.28
75	56.60	49.20	56.39	49.45	56.17	49.70	55.95	49.94
76	57.36	49.86	57.14	50.11	56.92	50.36	56.70	50.61
77	58.11	50.52	57.89	50.77	57.67	51.02	57.45	51.27
78	58.87	51.17	58.64	51.43	58.42	51.68	58.19	51.94
79	59.62	51.83	59.40	52.09	59.17	52.35	58.94	52.60
80	60.38	52.48	60.15	52.75	59.92	53.01	59.68	53.27
81	61.13	53.14	60.90	53.41	60.67	53.67	60.43	53.94
82	61.89	53.80	61.65	54.07	61.41	54.33	61.18	54.60
83	62.64	54.45	62.40	54.73	62.16	55.00	61.92	55.27
84	63.40	55.11	63.15	55.38	62.91	55.66	62.67	55.93
85	64.15	55.76	63.91	56.04	63.66	56.32	63.41	56.60
86	64.90	56.42	64.66	56.70	64.41	56.99	64.16	57.27
87	65.66	57.08	65.41	57.36	65.16	57.65	64.91	57.93
88	66.41	57.73	66.16	58.02	65.91	58.31	65.65	58.60
89	67.17	58.39	66.91	58.68	66.66	58.97	66.40	59.26
90	67.92	59.05	67.67	59.34	67.41	59.64	67.15	59.93
91	68.68	59.70	68.42	60.00	68.15	60.30	67.89	60.60
92	69.43	60.36	69.17	60.66	68.90	60.96	68.64	61.29
93	70.19	61.01	69.92	61.32	69.65	61.62	69.38	61.93
94	70.94	61.67	70.67	61.98	70.40	62.29	70.13	62.59
95	71.70	62.33	71.42	62.64	71.15	62.95	70.88	63.26
96	72.45	62.98	72.18	63.30	71.90	63.61	71.62	63.92
97	73.21	63.64	72.93	63.96	72.65	64.27	72.37	64.59
98	73.96	64.29	73.68	64.62	73.40	64.94	73.11	65.26
99	74.72	64.95	74.43	65.28	74.15	65.60	73.86	65.92
100	75.47	65.61	75.18	65.93	74.90	66.26	74.61	66.59
101	76.23	66.26	75.94	66.59	75.64	66.92	75.35	67.25
102	76.98	66.92	76.69	67.25	76.39	67.59	76.10	67.92
103	77.74	67.57	77.44	67.91	77.14	68.25	76.84	68.59
104	78.49	68.23	78.19	68.57	77.89	68.91	77.59	69.25
105	79.24	68.89	78.94	69.23	78.64	69.58	78.34	69.92
106	80.00	69.54	79.70	69.89	79.39	70.24	79.08	70.58
107	80.75	70.20	80.45	70.55	80.14	70.90	79.83	71.25
108	81.51	70.85	81.20	71.21	80.89	71.56	80.57	71.92
109	82.26	71.51	81.95	71.87	81.64	72.23	81.32	72.58
110	83.02	72.17	82.70	72.53	82.38	72.89	82.07	73.25
111	83.77	72.82	83.45	73.19	83.13	73.55	82.81	73.91
112	84.53	73.48	84.21	73.85	83.88	74.21	83.56	74.58
113	85.28	74.13	84.96	74.51	84.63	74.88	84.30	75.24
114	86.04	74.79	85.71	75.17	85.38	75.54	85.05	75.91
115	86.79	75.45	86.46	75.82	86.13	76.20	85.80	76.59
116	87.55	76.10	87.21	76.48	86.88	76.86	86.54	77.24
117	88.30	76.76	87.97	77.14	87.63	77.53	87.29	77.91
118	89.06	77.42	88.72	77.80	88.38	78.19	88.03	78.57
119	89.81	78.07	89.47	78.46	89.13	78.85	88.78	79.24
120	90.57	78.73	90.22	79.12	89.87	79.51	89.53	79.91
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat
	0′		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
1	0.74	0.67	0.74	0.67	0.74	0.68	0.73	0.68
2	1.49	1.34	1.48	1.34	1.47	1.35	1.47	1.36
3	2.23	2.01	2.22	2.02	2.21	2.03	2.20	2.04
4	2.97	2.68	2.96	2.69	2.95	2.70	2.94	2.72
5	3.72	3.35	3.70	3.36	3.69	3.38	3.67	3.39
6	4.46	4.01	4.44	4.03	4.42	4.05	4.41	4.07
7	5.20	4.68	5.18	4.71	5.16	4.73	5.14	4.75
8	5.95	5.35	5.92	5.38	5.90	5.40	5.87	5.43
9	6.69	6.02	6.66	6.05	6.64	6.08	6.61	6.11
10	7.43	6.69	7.40	6.72	7.37	6.76	7.34	6.79
11	8.17	7.36	8.14	7.40	8.11	7.43	8.08	7.47
12	8.92	8.03	8.88	8.07	8.85	8.11	8.81	8.15
13	9.66	8.70	9.62	8.74	9.58	8.78	9.55	8.82
14	10.40	9.37	10.36	9.41	10.32	9.46	10.28	9.50
15	11.15	10.04	11.10	10.09	11.06	10.13	11.01	10.18
16	11.89	10.71	11.84	10.76	11.80	10.81	11.75	10.86
17	12.63	11.38	12.58	11.43	12.53	11.48	12.48	11.54
18	13.38	12.04	13.32	12.10	13.27	12.16	13.22	12.22
19	14.12	12.71	14.06	12.77	14.01	12.84	13.95	12.90
20	14.86	13.38	14.80	13.45	14.75	13.51	14.69	13.58
21	15.61	14.05	15.54	14.12	15.48	14.19	15.42	14.25
22	16.35	14.72	16.28	14.79	16.22	14.86	16.16	14.93
23	17.09	15.39	17.02	15.46	16.96	15.54	16.89	15.61
24	17.84	16.06	17.77	16.14	17.69	16.21	17.62	16.29
25	18.58	16.73	18.51	16.81	18.43	16.89	18.36	16.97
26	19.32	17.40	19.25	17.48	19.17	17.57	19.09	17.65
27	20.06	18.07	19.99	18.15	19.91	18.24	19.83	18.33
28	20.81	18.74	20.73	18.83	20.64	18.92	20.56	19.01
29	21.55	19.40	21.47	19.50	21.38	19.59	21.30	19.69
30	22.29	20.07	22.21	20.17	22.12	20.27	22.03	20.36
31	23.04	20.74	22.95	20.84	22.86	20.94	22.76	21.04
32	23.78	21.41	23.69	21.52	23.59	21.62	23.50	21.72
33	24.52	22.08	24.43	22.19	24.33	22.29	24.23	22.40
34	25.27	22.75	25.17	22.86	25.07	22.97	24.97	23.08
35	26.01	23.42	25.91	23.53	25.80	23.65	25.70	23.76
36	26.75	24.09	26.65	24.21	26.54	24.32	26.44	24.44
37	27.50	24.76	27.39	24.88	27.28	25.00	27.17	25.12
38	28.24	25.43	28.13	25.55	28.02	25.67	27.90	25.79
39	28.98	26.10	28.87	26.22	28.75	26.35	28.64	26.47
40	29.73	26.77	29.61	26.89	29.40	27.02	29.37	27.15
41	30.47	27.43	30.35	27.57	30.23	27.70	30.11	27.83
42	31.21	28.10	31.09	28.24	30.97	28.37	30.84	28.51
43	31.96	28.77	31.83	28.91	31.70	29.05	31.58	29.19
44	32.70	29.44	32.57	29.58	32.44	29.73	32.31	29.87
45	33.44	30.11	33.31	30.26	33.18	30.40	33.04	30.55
46	34.18	30.78	34.05	30.93	33.91	31.08	33.78	31.22
47	34.93	31.45	34.79	31.60	34.65	31.75	34.51	31.90
48	35.67	32.12	35.53	32.27	35.39	32.43	35.25	32.58
49	36.41	32.79	36.27	32.95	36.13	33.10	35.98	33.26
50	37.16	33.46	37.01	33.62	36.80	33.78	36.72	33.94
51	37.90	34.13	37.75	34.29	37.60	34.46	37.45	34.62
52	38.64	34.79	38.49	34.96	38.34	35.13	38.18	35.30
53	39.39	35.46	39.23	35.64	39.08	35.81	38.92	35.98
54	40.13	36.13	39.97	36.31	39.81	36.48	39.65	36.66
55	40.87	36.80	40.71	36.98	40.55	37.16	40.39	37.33
56	41.62	37.47	41.45	37.65	41.29	37.83	41.12	38.01
57	42.36	38.14	42.19	38.32	42.02	38.51	41.86	38.69
58	43.10	38.81	42.93	39.00	42.76	39.18	42.59	39.37
59	43.85	39.48	43.67	39.67	43.50	39.86	43.32	40.05
60	44.59	40.15	44.41	40.34	44.24	40.54	44.06	40.73
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

47 DEGREES.

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
61	45.33	40.82	45.15	41.01	44.97	41.21	44.79	41.41
62	46.07	41.49	45.89	41.69	45.71	41.89	45.53	42.09
63	46.82	42.16	46.63	42.36	46.45	42.56	46.26	42.76
64	47.56	42.82	47.37	43.03	47.19	43.24	47.00	43.44
65	48.30	43.49	48.11	43.70	47.92	43.91	47.73	44.12
66	49.05	44.16	48.85	44.38	48.66	44.59	48.47	44.80
67	49.79	44.83	49.59	45.05	49.40	45.26	49.20	45.48
68	50.53	45.50	50.33	45.72	50.13	45.94	49.93	46.16
69	51.28	46.17	51.07	46.39	50.87	46.62	50.67	46.84
70	52.02	46.84	51.82	47.07	51.61	47.29	51.40	47.52
71	52.76	47.51	52.56	47.74	52.35	47.97	52.14	48.19
72	53.51	48.18	53.30	48.41	53.08	48.64	52.87	48.87
73	54.25	48.85	54.04	49.08	53.82	49.32	53.61	49.55
74	54.99	49.52	54.78	49.76	54.56	49.99	54.34	50.23
75	55.74	50.18	55.52	50.43	55.30	50.67	55.07	50.91
76	56.48	50.85	56.26	51.10	56.03	51.34	55.81	51.59
77	57.22	51.52	57.00	51.77	56.77	52.02	56.54	52.27
78	57.97	52.19	57.74	52.44	57.51	52.70	57.28	52.95
79	58.71	52.86	58.48	53.12	58.24	53.37	58.01	53.63
80	59.45	53.53	59.22	53.79	58.98	54.05	58.75	54.30
81	60.19	54.20	59.96	54.46	59.72	54.72	59.48	54.98
82	60.94	54.87	60.70	55.13	60.46	55.40	60.21	55.66
83	61.68	55.54	61.44	55.81	61.19	56.07	60.95	56.34
84	62.42	56.21	62.18	56.48	61.93	56.75	61.68	57.02
85	63.17	56.88	62.92	57.15	62.67	57.43	62.42	57.70
86	63.91	57.55	63.66	57.82	63.41	58.10	63.15	58.38
87	64.65	58.21	64.40	58.50	64.14	58.78	63.89	59.06
88	65.40	58.88	65.14	59.17	64.88	59.45	64.62	59.73
89	66.14	59.55	65.88	59.84	65.62	60.13	65.35	60.41
90	66.88	60.22	66.62	60.51	66.35	60.80	66.09	61.09
91	67.63	60.89	67.36	61.19	67.09	61.48	66.82	61.77
92	68.37	61.56	68.10	61.86	67.83	62.15	67.56	62.45
93	69.11	62.23	68.84	62.53	68.57	62.83	68.29	63.13
94	69.86	62.90	69.58	63.20	69.30	63.51	69.03	63.81
95	70.60	63.57	70.32	63.87	70.04	64.18	69.76	64.49
96	71.34	64.24	71.06	64.55	70.78	64.86	70.49	65.16
97	72.08	64.91	71.80	65.22	71.52	65.53	71.23	65.84
98	72.83	65.57	72.54	65.89	72.25	66.21	71.96	66.52
99	73.57	66.24	73.28	66.56	72.99	66.88	72.70	67.20
100	74.31	66.91	74.02	67.24	73.73	67.56	73.43	67.88
101	75.06	67.58	74.76	67.91	74.46	68.23	74.17	68.56
102	75.80	68.25	75.50	68.58	75.20	68.91	74.90	69.24
103	76.54	68.92	76.24	69.25	75.94	69.59	75.64	69.92
104	77.29	69.59	76.98	69.93	76.68	70.26	76.37	70.60
105	78.03	70.26	77.72	70.60	77.41	70.94	77.10	71.27
106	78.77	70.93	78.46	71.27	78.15	71.61	77.84	71.95
107	79.51	71.60	79.20	71.94	78.89	72.29	78.57	72.63
108	80.26	72.27	79.94	72.62	79.63	72.96	79.31	73.31
109	81.00	72.94	80.68	73.29	80.36	73.64	80.04	73.99
110	81.75	73.60	81.42	73.96	81.10	74.31	80.78	74.67
111	82.49	74.27	82.16	74.63	81.84	74.99	81.51	75.35
112	83.23	74.94	82.90	75.31	82.57	75.67	82.24	76.03
113	83.98	75.61	83.64	75.98	83.31	76.34	82.98	76.70
114	84.72	76.28	84.38	76.65	84.05	77.02	83.71	77.38
115	85.46	76.95	85.12	77.32	84.79	77.69	84.45	78.06
116	86.20	77.62	85.87	77.99	85.52	78.37	85.18	78.74
117	86.95	78.29	86.61	78.67	86.26	79.04	85.92	79.42
118	87.69	78.96	87.35	79.34	87.00	79.72	86.65	80.10
119	88.43	79.63	88.09	80.01	87.74	80.40	87.38	80.78
120	89.18	80.30	88.83	80.68	88.47	81.07	88.12	81.46
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.
1	0.73	0.68	0.73	0.69	0.73	0.69	0.72	0.69
2	1.46	1.36	1.46	1.37	1.45	1.38	1.44	1.38
3	2.19	2.05	2.19	2.06	2.18	2.07	2.17	2.07
4	2.93	2.73	2.91	2.74	2.90	2.75	2.89	2.77
5	3.66	3.41	3.64	3.43	3.63	3.44	3.61	3.46
6	4.39	4.09	4.37	4.11	4.35	4.13	4.33	4.15
7	5.12	4.77	5.10	4.80	5.08	4.82	5.06	4.84
8	5.85	5.46	5.83	5.48	5.80	5.51	5.78	5.53
9	6.58	6.14	6.56	6.17	6.53	6.20	6.50	6.22
10	7.31	6.82	7.28	6.85	7.25	6.88	7.22	6.92
11	8.04	7.50	8.01	7.54	7.98	7.57	7.95	7.61
12	8.78	8.18	8.74	8.22	8.70	8.26	8.67	8.30
13	9.51	8.87	9.47	8.91	9.43	8.95	9.39	8.99
14	10.24	9.55	10.20	9.59	10.16	9.64	10.11	9.68
15	10.97	10.23	10.93	10.28	10.88	10.33	10.84	10.37
16	11.70	10.91	11.65	10.96	11.61	11.01	11.56	11.06
17	12.43	11.59	12.38	11.65	12.33	11.70	12.28	11.76
18	13.16	12.28	13.11	12.33	13.06	12.39	13.00	12.45
19	13.90	12.96	13.84	13.02	13.78	13.08	13.72	13.14
20	14.63	13.64	14.57	13.70	14.51	13.77	14.45	13.83
21	15.36	14.32	15.30	14.39	15.23	14.46	15.17	14.52
22	16.09	15.00	16.02	15.07	15.96	15.14	15.89	15.21
23	16.82	15.69	16.75	15.76	16.68	15.83	16.61	15.90
24	17.55	16.37	17.48	16.44	17.41	16.52	17.34	16.60
25	18.28	17.05	18.21	17.13	18.13	17.21	18.06	17.29
26	19.02	17.73	18.94	17.81	18.86	17.90	18.78	17.98
27	19.75	18.41	19.67	18.50	19.59	18.59	19.50	18.67
28	20.48	19.10	20.39	19.19	20.31	19.27	20.23	19.36
29	21.21	19.78	21.12	19.87	21.04	19.96	20.95	20.05
30	21.94	20.46	21.85	20.56	21.76	20.65	21.67	20.75
31	22.67	21.14	22.58	21.24	22.49	21.34	22.39	21.44
32	23.40	21.82	23.31	21.93	23.21	22.03	23.12	22.13
33	24.13	22.51	24.04	22.61	23.94	22.72	23.84	22.82
34	24.87	23.19	24.76	23.30	24.66	23.40	24.56	23.51
35	25.60	23.87	25.49	23.98	25.39	24.09	25.28	24.20
36	26.33	24.55	26.22	24.67	26.11	24.78	26.01	24.89
37	27.06	25.23	26.95	25.35	26.84	25.47	26.73	25.59
38	27.79	25.92	27.68	26.04	27.56	26.16	27.45	26.28
39	28.52	26.60	28.41	26.72	28.29	26.85	28.17	26.97
40	29.25	27.28	29.13	27.41	29.01	27.53	28.89	27.66
41	29.99	27.96	29.86	28.09	29.74	28.22	29.62	28.35
42	30.72	28.64	30.59	28.78	30.47	28.91	30.34	29.04
43	31.45	29.33	31.32	29.46	31.19	29.60	31.06	29.74
44	32.18	30.01	32.05	30.15	31.92	30.29	31.78	30.43
45	32.91	30.69	32.78	30.83	32.64	30.98	32.51	31.12
46	33.64	31.37	33.51	31.52	33.37	31.66	33.23	31.81
47	34.37	32.05	34.23	32.20	34.09	32.35	33.95	32.50
48	35.10	32.74	34.96	32.89	34.82	33.04	34.67	33.19
49	35.84	33.42	35.69	33.57	35.54	33.73	35.40	33.88
50	36.57	34.10	36.42	34.26	36.27	34.42	36.12	34.58
51	37.30	34.78	37.15	34.94	36.99	35.11	36.84	35.27
52	38.03	35.46	37.88	35.63	37.72	35.79	37.56	35.96
53	38.76	36.15	38.60	36.31	38.44	36.48	38.29	36.65
54	39.49	36.83	39.33	37.00	39.17	37.17	39.01	37.34
55	40.22	37.51	40.06	37.69	39.90	37.86	39.73	38.03
56	40.96	38.19	40.79	38.37	40.62	38.55	40.45	38.72
57	41.69	38.87	41.52	39.06	41.35	39.24	41.17	39.42
58	42.42	39.56	42.25	39.74	42.07	39.92	41.90	40.11
59	43.15	40.24	42.97	40.43	42.80	40.61	42.62	40.80
60	43.88	40.92	43.70	41.11	43.52	41.30	43.34	41.49
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0′		45′		30′		15′	

46 DEGREES.

Dist	0'		15'		30'		45'	
	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
61	44.61	41.60	44.43	41.80	44.25	41.99	44.06	42.18
62	45.34	42.28	45.16	42.48	44.97	42.68	44.79	42.87
63	46.08	42.97	45.89	43.17	45.70	43.37	45.51	43.57
64	46.81	43.65	46.62	43.85	46.42	44.05	46.23	44.26
65	47.54	44.33	47.34	44.54	47.15	44.74	46.95	44.95
66	48.27	45.01	48.07	45.22	47.87	45.43	47.68	45.64
67	49.00	45.69	48.80	45.91	48.60	46.12	48.40	46.33
68	49.73	46.38	49.53	46.59	49.33	46.81	49.12	47.02
69	50.46	47.06	50.26	47.28	50.05	47.50	49.84	47.71
70	51.19	47.74	50.99	47.96	50.78	48.18	50.57	48.41
71	51.93	48.42	51.71	48.65	51.50	48.87	51.29	49.10
72	52.66	49.10	52.44	49.33	52.23	49.56	52.01	49.79
73	53.39	49.79	53.17	50.02	52.95	50.25	52.73	50.48
74	54.12	50.47	53.90	50.70	53.68	50.94	53.45	51.17
75	54.85	51.15	54.63	51.39	54.40	51.63	54.18	51.86
76	55.58	51.83	55.36	52.07	55.13	52.31	54.90	52.55
77	56.31	52.51	56.08	52.76	55.85	53.00	55.62	53.25
78	57.05	53.20	56.81	53.44	56.58	53.69	56.34	53.94
79	57.78	53.88	57.54	54.13	57.30	54.38	57.07	54.63
80	58.51	54.56	58.27	54.81	58.03	55.07	57.79	55.32
81	59.24	55.24	59.00	55.50	58.76	55.76	58.51	56.01
82	59.97	55.92	59.73	56.18	59.48	56.45	59.23	56.70
83	60.70	56.61	60.45	56.87	60.21	57.13	59.96	57.40
84	61.43	57.29	61.18	57.56	60.93	57.82	60.68	58.09
85	62.17	57.97	61.91	58.24	61.66	58.51	61.40	58.78
86	62.90	58.65	62.64	58.93	62.38	59.20	62.12	59.47
87	63.63	59.33	63.37	59.61	63.11	59.89	62.85	60.16
88	64.36	60.02	64.10	60.30	63.83	60.58	63.57	60.85
89	65.09	60.70	64.82	60.98	64.56	61.26	64.29	61.54
90	65.82	61.38	65.55	61.67	65.28	61.95	65.01	62.24
91	66.55	62.06	66.28	62.35	66.01	62.64	65.74	62.93
92	67.28	62.74	67.01	63.04	66.73	63.33	66.46	63.62
93	68.02	63.43	67.74	63.72	67.46	64.02	67.18	64.31
94	68.75	64.11	68.47	64.41	68.19	64.71	67.90	65.00
95	69.48	64.79	69.20	65.09	68.91	65.39	68.62	65.69
96	70.21	65.47	69.92	65.78	69.64	66.08	69.35	66.39
97	70.94	66.15	70.65	66.46	70.36	66.77	70.07	67.08
98	71.67	66.84	71.38	67.15	71.09	67.46	70.79	67.77
99	72.40	67.52	72.11	67.83	71.81	68.15	71.51	68.46
100	73.14	68.20	72.84	68.52	72.54	68.84	72.24	69.15
101	73.87	68.88	73.57	69.20	73.26	69.52	72.96	69.84
102	74.60	69.56	74.29	69.89	73.99	70.21	73.68	70.53
103	75.33	70.25	75.02	70.57	74.71	70.90	74.40	71.23
104	76.06	70.93	75.75	71.26	75.44	71.59	75.13	71.92
105	76.79	71.61	76.48	71.94	76.16	72.28	75.85	72.61
106	77.52	72.29	77.21	72.63	76.89	72.97	76.57	73.30
107	78.25	72.97	77.94	73.31	77.61	73.65	77.29	73.99
108	78.99	73.66	78.66	74.00	78.34	74.34	78.02	74.68
109	79.72	74.34	79.39	74.68	79.07	75.03	78.74	75.37
110	80.45	75.02	80.12	75.37	79.79	75.72	79.46	76.07
111	81.18	75.70	80.85	76.06	80.52	76.41	80.18	76.7
112	81.91	76.38	81.58	76.74	81.24	77.10	80.90	77.4
113	82.64	77.07	82.31	77.43	81.97	77.78	81.63	78.1
114	83.37	77.75	83.03	78.11	82.69	78.47	82.35	78.8
115	84.11	78.43	83.76	78.80	83.42	79.16	83.07	79.5
116	84.84	79.11	84.49	79.48	84.14	79.85	83.79	80.2
117	85.57	79.79	85.22	80.17	84.87	80.54	84.52	80.9
118	86.30	80.48	85.95	80.85	85.59	81.23	85.24	81.6
119	87.03	81.16	86.68	81.54	86.32	81.91	85.96	82.2
120	87.76	81.84	87.40	82.22	87.04	82.60	86.68	82.9
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0'		45'		30'		15'	

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.	Lat. Dep.
1	0.72	0.69	0.72	0.70	0.71	0.70	0.71	0.70	0.71
2	1.44	1.39	1.43	1.40	1.43	1.40	1.42	1.41	1.41
3	2.16	2.08	2.15	2.09	2.14	2.10	2.13	2.11	2.12
4	2.88	2.78	2.87	2.79	2.85	2.80	2.84	2.82	2.83
5	3.60	3.47	3.58	3.49	3.57	3.50	3.55	3.52	3.54
6	4.32	4.17	4.30	4.19	4.28	4.21	4.26	4.22	4.24
7	5.04	4.86	5.01	4.88	4.99	4.91	4.97	4.93	4.95
8	5.75	5.56	5.73	5.58	5.71	5.61	5.68	5.63	5.66
9	6.47	6.25	6.45	6.28	6.42	6.31	6.39	6.34	6.36
10	7.19	6.95	7.16	6.98	7.13	7.01	7.10	7.04	7.07
11	7.91	7.64	7.88	7.68	7.85	7.71	7.81	7.74	7.78
12	8.63	8.34	8.60	8.37	8.56	8.41	8.52	8.45	8.49
13	9.35	9.03	9.31	9.07	9.27	9.11	9.23	9.15	9.19
14	10.07	9.73	10.03	9.77	9.99	9.81	9.94	9.86	9.90
15	10.79	10.42	10.74	10.47	10.70	10.51	10.65	10.56	10.61
16	11.51	11.11	11.46	11.16	11.41	11.21	11.36	11.26	11.31
17	12.23	11.81	12.18	11.86	12.13	11.92	12.07	11.97	12.02
18	12.95	12.50	12.89	12.56	12.84	12.62	12.78	12.67	12.73
19	13.67	13.20	13.61	13.26	13.55	13.32	13.49	13.38	13.44
20	14.39	13.89	14.33	13.96	14.27	14.02	14.20	14.08	14.14
21	15.11	14.59	15.04	14.65	14.98	14.72	14.91	14.78	14.85
22	15.83	15.28	15.76	15.35	15.69	15.42	15.62	15.49	15.56
23	16.54	15.98	16.47	16.05	16.40	16.12	16.33	16.19	16.26
24	17.26	16.67	17.19	16.75	17.12	16.82	17.04	16.90	16.97
25	17.98	17.37	17.91	17.44	17.83	17.52	17.75	17.60	17.68
26	18.70	18.06	18.62	18.14	18.54	18.22	18.46	18.30	18.38
27	19.42	18.76	19.34	18.84	19.26	18.92	19.17	19.01	19.09
28	20.14	19.45	20.06	19.54	19.97	19.63	19.89	19.71	19.80
29	20.86	20.15	20.77	20.24	20.68	20.33	20.60	20.42	20.51
30	21.58	20.84	21.49	20.93	21.40	21.03	21.31	21.12	21.21
31	22.30	21.53	22.21	21.63	22.11	21.73	22.02	21.82	21.92
32	23.02	22.23	22.92	22.33	22.82	22.43	22.73	22.53	22.63
33	23.74	22.92	23.64	23.03	23.54	23.13	23.44	23.23	23.33
34	24.46	23.62	24.35	23.72	24.25	23.83	24.15	23.94	24.04
35	25.18	24.31	25.07	24.42	24.96	24.53	24.86	24.64	24.75
36	25.90	25.01	25.79	25.12	25.68	25.23	25.57	25.34	25.46
37	26.62	25.70	26.50	25.82	26.39	25.93	26.28	26.05	26.16
38	27.33	26.40	27.22	26.52	27.10	26.63	26.99	26.75	26.87
39	28.05	27.09	27.94	27.21	27.82	27.34	27.70	27.46	27.58
40	28.77	27.79	28.65	27.91	28.53	28.04	28.41	28.16	28.28
41	29.49	28.48	29.37	28.61	29.24	28.74	29.12	28.86	28.99
42	30.21	29.18	30.08	29.31	29.96	29.44	29.83	29.57	29.70
43	30.93	29.87	30.80	30.01	30.67	30.14	30.54	30.27	30.41
44	31.65	30.56	31.52	30.70	31.38	30.84	31.25	30.98	31.11
45	32.37	31.26	32.23	31.40	32.10	31.54	31.96	31.68	31.82
46	33.09	31.95	32.95	32.10	32.81	32.24	32.67	32.38	32.53
47	33.81	32.65	33.67	32.80	33.52	32.94	33.38	33.09	33.23
48	34.53	33.34	34.38	33.49	34.24	33.64	34.09	33.79	33.94
49	35.25	34.04	35.10	34.19	34.95	34.34	34.80	34.50	34.65
50	35.97	34.73	35.82	34.89	35.66	35.05	35.51	35.20	35.36
51	36.69	35.43	36.53	35.59	36.38	35.75	36.22	35.90	36.06
52	37.41	36.12	37.25	36.29	37.09	36.45	36.93	36.61	36.77
53	38.12	36.82	37.96	36.98	37.80	37.15	37.64	37.31	37.48
54	38.84	37.51	38.68	37.68	38.52	37.85	38.35	38.02	38.18
55	39.56	38.21	39.40	38.38	39.23	38.55	39.06	38.72	38.89
56	40.28	38.90	40.11	39.08	39.94	39.25	39.77	39.42	39.60
57	41.00	39.60	40.83	39.77	40.66	39.95	40.48	40.13	40.31
58	41.72	40.29	41.55	40.47	41.37	40.65	41.19	40.83	41.01
59	42.44	40.98	42.26	41.17	42.08	41.35	41.90	41.54	41.72
60	43.16	41.68	42.98	41.87	42.80	42.05	42.61	42.24	42.43
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	D. L.
	0′		45′		30′		15′		0 M.

Dist.	0′ Lat.	0′ Dep.	15′ Lat.	15′ Dep.	30′ Lat.	30′ Dep.	45′ Lat.	45′ Dep.	0′ L. D.
61	43.88	42.37	43.69	42.57	43.51	42.76	43.32	42.94	43.13
62	44.60	43.07	44.41	43.26	44.22	43.46	44.03	43.65	43.84
63	45.32	43.76	45.13	43.96	44.93	44.16	44.74	44.35	44.55
64	46.04	44.46	45.84	44.66	45.65	44.86	45.45	45.06	45.25
65	46.76	45.15	46.56	45.36	46.36	45.56	46.16	45.76	45.96
66	47.48	45.85	47.28	46.05	47.07	46.26	46.87	46.47	46.67
67	48.20	46.54	47.99	46.75	47.79	46.96	47.58	47.17	47.38
68	48.92	47.24	48.71	47.45	48.50	47.66	48.29	47.87	48.08
69	49.63	47.93	49.42	48.15	49.21	48.36	49.00	48.58	48.79
70	50.35	48.63	50.14	48.85	49.93	49.06	49.71	49.28	49.50
71	51.07	49.32	50.86	49.54	50.64	49.76	50.42	49.99	50.20
72	51.79	50.02	51.57	50.24	51.35	50.47	51.13	50.69	50.91
73	52.51	50.71	52.29	50.94	52.07	51.17	51.84	51.39	51.62
74	53.23	51.40	53.01	51.64	52.78	51.87	52.55	52.10	52.33
75	53.95	52.10	53.72	52.33	53.49	52.57	53.26	52.80	53.03
76	54.67	52.79	54.44	53.03	54.21	53.27	53.97	53.51	53.74
77	55.39	53.49	55.16	53.73	54.92	53.97	54.68	54.21	54.45
78	56.11	54.18	55.87	54.43	55.63	54.67	55.39	54.91	55.15
79	56.83	54.88	56.59	55.13	56.35	55.37	56.10	55.62	55.86
80	57.55	55.57	57.30	55.82	57.06	56.07	56.81	56.32	56.57
81	58.27	56.27	58.02	56.52	57.77	56.77	57.52	57.03	57.28
82	58.99	56.96	58.74	57.22	58.49	57.47	58.24	57.73	57.98
83	59.71	57.66	59.45	57.92	59.20	58.18	58.95	58.43	58.69
84	60.42	58.35	60.17	58.61	59.91	58.88	59.66	59.14	59.40
85	61.14	59.05	60.89	59.31	60.63	59.58	60.37	59.84	60.10
86	61.86	59.74	61.60	60.01	61.34	60.28	61.08	60.55	60.81
87	62.58	60.44	62.32	60.71	62.05	60.98	61.79	61.25	61.52
88	63.30	61.13	63.03	61.41	62.77	61.68	62.50	61.95	62.23
89	64.02	61.82	63.75	62.10	63.48	62.38	63.21	62.66	62.93
90	64.74	62.52	64.47	62.80	64.19	63.08	63.92	63.36	63.64
91	65.46	63.21	65.18	63.50	64.91	63.78	64.63	64.07	64.35
92	66.18	63.91	65.90	64.20	65.62	64.48	65.34	64.77	65.05
93	66.90	64.60	66.62	64.89	66.33	65.18	66.05	65.47	65.76
94	67.62	65.30	67.33	65.59	67.05	65.89	66.76	66.18	66.47
95	68.34	65.99	68.05	66.29	67.76	66.59	67.47	66.88	67.18
96	69.06	66.69	68.76	66.99	68.47	67.29	68.18	67.59	67.88
97	69.78	67.38	69.48	67.69	69.19	67.99	68.89	68.29	68.59
98	70.50	68.08	70.20	68.38	69.90	68.69	69.60	68.99	69.30
99	71.21	68.77	70.91	69.08	70.61	69.39	70.31	69.70	70.00
100	71.93	69.47	71.63	69.78	71.33	70.09	71.02	70.40	70.71
101	72.65	70.16	72.35	70.48	72.04	70.79	71.73	71.11	71.42
102	73.37	70.86	73.06	71.17	72.75	71.49	72.44	71.81	72.12
103	74.09	71.55	73.78	71.87	73.46	72.19	73.15	72.51	72.83
104	74.81	72.24	74.50	72.57	74.18	72.89	73.86	73.22	73.54
105	75.53	72.94	75.21	73.27	74.89	73.60	74.57	73.92	74.25
106	76.25	73.63	75.93	73.97	75.60	74.30	75.28	74.63	74.95
107	76.97	74.33	76.64	74.66	76.32	75.00	75.99	75.33	75.66
108	77.69	75.02	77.36	75.36	77.03	75.70	76.70	76.03	76.37
109	78.41	75.72	78.08	76.06	77.74	76.40	77.41	76.74	77.07
110	79.13	76.41	78.79	76.76	78.46	77.10	78.12	77.44	77.78
111	79.85	77.11	79.51	77.45	79.17	77.80	78.83	78.15	78.49
112	80.57	77.80	80.23	78.15	79.88	78.50	79.54	78.85	79.20
113	81.29	78.50	80.94	78.85	80.60	79.20	80.25	79.55	79.90
114	82.00	79.19	81.66	79.55	81.31	79.90	80.96	80.26	80.61
115	82.72	79.89	82.37	80.25	82.02	80.60	81.67	80.96	81.32
116	83.44	80.58	83.09	80.94	82.74	81.31	82.38	81.67	82.02
117	84.16	81.28	83.81	81.64	83.45	82.01	83.09	82.37	82.73
118	84.88	81.97	84.52	82.34	84.16	82.71	83.80	83.07	83.44
119	85.60	82.66	85.24	83.04	84.88	83.41	84.51	83.78	84.15
120	86.32	83.36	85.96	83.73	85.59	84.11	85.22	84.48	84.85
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	L. D.
	0′		45′		30′		15′		0′

MEAN REFRACTION.

App. Alt.	Refr.	App. Alt.	Refr.	App. Alt.	Refr.	App. Alt.	Refr.	App. Alt.	Refr.
° '	' "	° '	' "	° '	' "	° '	' "	° '	' "
0 0	33 0	5 0	9 54	10 0	5 15	20 0	2 35	34 0	1 24
0 5	32 10	5 5	9 46	10 10	5 10	20 10	2 34	34 30	1 23
0 10	31 22	5 10	9 38	10 20	5 5	20 20	2 32	35 0	1 21
0 15	30 35	5 15	9 30	10 30	5 0	20 30	2 31	35 30	1 20
0 20	29 50	5 20	9 23	10 40	4 56	20 40	2 29	36 0	1 18
0 25	29 6	5 25	9 15	10 50	4 51	20 50	2 28	36 30	1 17
0 30	28 23	5 30	9 8	11 0	4 47	21 0	2 27	37 0	1 16
0 35	27 41	5 35	9 1	11 10	4 43	21 10	2 26	37 30	1 14
0 40	27 0	5 40	8 54	11 20	4 39	21 20	2 25	38 0	1 13
0 45	26 20	5 45	8 47	11 30	4 34	21 30	2 24	38 30	1 11
0 50	25 42	5 50	8 41	11 40	4 31	21 40	2 23	39 0	1 10
0 55	25 5	5 55	8 34	11 50	4 27	21 50	2 21	39 30	1 9
1 0	24 29	6 0	8 28	12 0	4 23	22 0	2 20	40 0	1 8
1 5	23 54	6 5	8 21	12 10	4 20	22 10	2 19	41 0	1 5
1 10	23 20	6 10	8 15	12 20	4 16	22 20	2 18	42 0	1 3
1 15	22 47	6 15	8 9	12 30	4 13	22 30	2 17	43 0	1 1
1 20	22 15	6 20	8 3	12 40	4 9	22 40	2 16	44 0	0 59
1 25	21 44	6 25	7 57	12 50	4 6	22 50	2 15	45 0	0 57
1 30	21 15	6 30	7 51	13 0	4 3	23 0	2 14	46 0	0 55
1 35	20 46	6 35	7 45	13 10	4 0	23 10	2 13	47 0	0 53
1 40	20 18	6 40	7 40	13 20	3 57	23 20	2 12	48 0	0 51
1 45	19 51	6 45	7 35	13 30	3 54	23 30	2 11	49 0	0 49
1 50	19 25	6 50	7 30	13 40	3 51	23 40	2 10	50 0	0 48
1 55	19 0	6 55	7 25	13 50	3 48	23 50	2 9	51 0	0 46
2 0	18 35	7 0	7 20	14 0	3 45	24 0	2 8	52 0	0 44
2 5	18 11	7 5	7 15	14 10	3 43	24 10	2 7	53 0	0 43
2 10	17 48	7 10	7 11	14 20	3 40	24 20	2 6	54 0	0 41
2 15	17 26	7 15	7 6	14 30	3 38	24 30	2 5	55 0	0 40
2 20	17 4	7 20	7 2	14 40	3 35	24 40	2 4	56 0	0 38
2 25	16 44	7 25	6 57	14 50	3 33	24 50	2 3	57 0	0 37
2 30	16 24	7 30	6 53	15 0	3 30	25 0	2 2	58 0	0 35
2 35	16 4	7 35	6 49	15 10	3 28	25 10	2 1	59 0	0 34
2 40	15 45	7 40	6 45	15 20	3 26	25 20	2 0	60 0	0 33
2 45	15 27	7 45	6 41	15 30	3 24	25 30	1 59	61 0	0 32
2 50	15 9	7 50	6 37	15 40	3 21	25 40	1 58	62 0	0 30
2 55	14 52	7 55	6 33	15 50	3 19	25 50	1 57	63 0	0 29
3 0	14 36	8 0	6 29	16 0	3 17	26 0	1 56	64 0	0 28
3 5	14 20	8 5	6 25	16 10	3 15	26 10	1 55	65 0	0 26
3 10	14 4	8 10	6 22	16 20	3 12	26 20	1 55	66 0	0 25
3 15	13 49	8 15	6 18	16 30	3 10	26 30	1 54	67 0	0 24
3 20	13 34	8 20	6 15	16 40	3 8	26 40	1 53	68 0	0 23
3 25	13 20	8 25	6 11	16 50	3 6	26 50	1 52	69 0	0 22
3 30	13 6	8 30	6 8	17 0	3 4	27 0	1 51	70 0	0 21
3 35	12 53	8 35	6 5	17 10	3 3	27 15	1 50	71 0	0 19
3 40	12 40	8 40	6 1	17 20	3 1	27 30	1 49	72 0	0 18
3 45	12 27	8 45	5 58	17 30	2 59	27 45	1 48	73 0	0 17
3 50	12 15	8 50	5 55	17 40	2 57	28 0	1 47	74 0	0 16
3 55	12 3	8 55	5 52	17 50	2 55	28 15	1 46	75 0	0 15
4 0	11 51	9 0	5 48	18 0	2 54	28 30	1 45	76 0	0 14
4 5	11 40	9 5	5 45	18 10	2 52	28 45	1 44	77 0	0 13
4 10	11 29	9 10	5 42	18 20	2 51	29 0	1 42	78 0	0 12
4 15	11 18	9 15	5 39	18 30	2 49	29 30	1 40	79 0	0 11
4 20	11 8	9 20	5 36	18 40	2 47	30 0	1 38	80 0	0 10
4 25	10 58	9 25	5 34	18 50	2 46	30 30	1 37	81 0	0 9
4 30	10 48	9 30	5 31	19 0	2 44	31 0	1 35	82 0	0 8
4 35	10 39	9 35	5 28	19 10	2 43	31 30	1 33	83 0	0 7
4 40	10 29	9 40	5 25	19 20	2 41	32 0	1 31	84 0	0 6
4 45	10 20	9 45	5 23	19 30	2 40	32 30	1 30	86 0	0 4
4 50	10 11	9 50	5 20	19 40	2 38	33 0	1 28	88 0	0 2
4 55	10 2	9 55	5 18	19 50	2 37	33 30	1 26	90 0	0 0

TABLE 7. Sun's Parallax in Alt.		TABLE 8. Dip of the Horizon.						TABLE 9. Dip at differ. Distances from the Observer.						
Altit.	Parall.	Height	Dip		Height	Dip		Miles.	Height of the Eye in Feet					
°	"	Feet	′	″	Feet	′	″		5	10	15	20	25	30
0	9	1	0	58	19	4	11	1/4	11	23′	34′	45′	57′	68′
10	9	2	1	21	20	4	17	1/2	6	12	17	23	28	34
20	8	3	1	40	21	4	23	3/4	4	8	12	15	19	23
30	8	4	1	56	22	4	30	1	3	6	9	12	15	17
40	7	5	2	9	23	4	36	1 1/4	3	5	7	10	12	14
50	6	6	2	21	24	4	42	1 1/2	3	4	6	8	10	12
55	5	7	2	33	26	4	52	2	2	4	5	7	8	9
60	4	8	2	44	28	5	5	2 1/2	2	3	4	6	7	8
65	4	9	2	53	30	5	15	3	2	3	4	5	6	7
70	3	10	3	2	35	5	39	3 1/2	2	3	4	5	6	6
75	2	11	3	10	40	6	4	4	2	3	4	5	5	6
80	2	12	3	19	45	6	27	5	2	3	4	4	5	6
85	1	13	3	27	50	6	46	6	2	3	4	4	5	5
90	0	14	3	36	60	7	25							
		15	3	42	70	8	1							
		16	3	50	80	8	34							
		17	3	57	90	9	6							
		18	4	4	100	9	35							

TABLE 10.

The Semi-diameter of the Sun.

Month	Day.	Sun's Semi-di.	Month	Day.	Sun's Semi-di.	Month	Day.	Sun's Semi-di.
January.	1	16′ 19″	May.	1	15′ 54″	September.	1	15′ 55″
	7	16 19		7	15 53		7	15 56
	13	16 19		13	15 52		13	15 58
	19	16 18		19	15 51		19	15 59
	25	16 17		25	15 50		25	16 1
February.	1	16 16	June.	1	15 49	October.	1	16 3
	7	16 15		7	15 48		7	16 4
	13	16 14		13	15 47		13	16 6
	19	16 13		19	15 47		19	16 8
	25	16 12		25	15 47		25	16 9
March.	1	16 10	July.	1	15 47	November.	1	16 11
	7	16 9		7	15 47		7	16 13
	13	16 7		13	15 47		13	16 14
	19	16 6		19	15 48		19	16 15
	25	16 4		25	15 48		25	16 16
April.	1	16 2	August.	1	15 49	December.	1	16 17
	7	16 1		7	15 50		7	16 18
	13	15 59		13	15 51		13	16 18
	19	15 57		19	15 52		19	16 19
	25	15 56		25	15 53		25	16 19

TABLE II.

Apparent Time of Transit of Pole Star.

This table is adapted to leap year, particularly 1808. In order to make it serve for other years, the time of transit must be taken for the day following that given in the months of January and February. For the first year after leap year, one minute is to be added to the time of transit given in the table; two minutes for the second, and three minutes for the third after leap year.

Again, to reduce this table to a different meridian than that to which it is adapted, viz. Greenwich; if the longitude is between 45° E, and 45° W, there is no correction to be applied. If the longitude is between 45° and 135° E, one minute is to be added; but if it is between 45° and 135° W, one minute is to be subtracted. If the longitude is between 135° E, and 180°, two minutes are to be added, but subtracted if the given longitude is between 135° W, and 180°.

This table is useful to find the time when the altitude of the pole star ought to be observed, to find the latitude by its meridian altitude; it is also useful in finding the variation of the compass by the pole star.

Days.	Jan.	Feb.	Marc	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec
	P. M	P. M.	P. M	P. M.	A. M.	A. M.	A. M.	A. M.	A. M.	A. M.	P. M.	P. M.
1	6h 9′	3h 56′	2h 4′	0h 0′	10h 19′	8h 17′	6h 13′	4h 9′	2h 13′	0h 25′	10h 25′	8h 23′
2	6 4	3 52	2 0	0 7	10 15	8 13	6 9	4 5	2 10	0 21	10 21	8 18
3	6 0	3 48	1 57	0 3	10 12	8 9	6 5	4 1	2 6	0 18	10 17	8 13
4	5 55	3 44	1 53	0 0	10 8	8 5	6 1	3 57	2 3	0 14	10 13	8 9
				A. M.								
5	5 51	3 40	1 49	11 56	10 4	8 1	5 57	3 53	1 59	0 10	10 8	8 5
6	5 47	3 36	1 45	11 52	10 0	7 57	5 53	3 49	1 55	0 7	10 5	8 0
7	5 42	3 32	1 42	11 49	9 56	7 53	5 49	3 45	1 52	0 3	10 1	7 56
										P. M. 12 0		
8	5 38	3 28	1 38	11 45	9 52	7 49	5 44	3 42	1 48	11 56	9 57	7 52
9	5 33	3 24	1 34	11 41	9 48	7 45	5 40	3 38	1 45	11 52	9 53	7 47
10	5 29	3 20	1 31	11 38	9 45	7 41	5 36	3 34	1 41	11 48	9 49	7 43
11	5 25	3 16	1 27	11 37	9 41	7 36	5 32	3 30	1 37	11 45	9 45	7 38
12	5 20	3 12	1 23	11 33	9 37	7 32	5 28	3 26	1 34	11 41	9 41	7 34
13	5 16	3 8	1 20	11 20	9 33	7 28	5 24	3 23	1 30	11 37	9 37	7 30
14	5 12	3 4	1 16	11 23	9 29	7 24	5 20	3 19	1 27	11 34	9 33	7 25
15	5 7	3 0	1 12	11 19	9 25	7 20	5 16	3 15	1 23	11 30	9 29	7 21
16	5 3	2 57	1 9	11 16	9 21	7 16	5 12	3 11	1 19	11 26	9 25	7 16
17	4 59	2 53	1 5	11 12	9 17	7 11	5 8	3 8	1 16	11 22	9 20	7 12
18	4 55	2 50	1 1	11 8	9 13	7 7	5 4	3 4	1 12	11 19	9 16	7 7
19	4 50	2 46	0 58	11 4	9 9	7 3	5 0	3 0	1 9	11 15	9 12	7 3
20	4 46	2 42	0 54	11 1	9 5	6 59	4 56	2 57	1 5	11 11	9 8	6 59
21	4 42	2 38	0 50	10 57	9 1	6 55	4 52	2 54	1 1	11 7	9 4	6 54
22	4 38	2 34	0 47	10 53	8 58	6 51	4 48	2 50	0 58	11 4	9 0	6 50
23	4 33	2 30	0 43	10 50	8 54	6 47	4 44	2 46	0 54	11 0	8 56	6 45
24	4 29	2 27	0 40	10 46	8 50	6 42	4 40	2 43	0 51	10 56	8 52	6 41
25	4 25	2 23	0 36	10 42	8 46	6 38	4 36	2 39	0 47	10 52	8 48	6 36
26	4 21	2 19	0 32	10 38	8 42	6 34	4 32	2 35	0 43	10 48	8 44	6 32
27	4 17	2 15	0 29	10 34	8 38	6 20	4 28	2 32	0 40	10 44	8 39	6 27
28	4 13	2 11	0 25	10 31	8 34	6 26	4 24	2 28	0 36	10 41	8 35	6 23
29	4 8	2 8	0 21	10 27	8 30	6 22	4 20	2 24	0 33	10 37	8 31	6 19
30	4 4		0 18	10 23	8 26	6 17	4 16	2 21	0 29	10 33	8 26	6 14
31	4 0		0 14		8 22		4 12	2 17		10 29		6 10

Difference of Altitude of the Pole Star and the Pole, at different distances of the Star from the Meridian.

As the pole star is generally known, that no opportunity, therefore, may be lost for determining the latitude, this table is inserted, the use of which is as follows :—

Find the interval between the time of observation of the altitude of the pole star, and that of its passing the meridian, and take out the corresponding equation from the table; which added to, or subtracted from the true altitude of the pole star, will give the latitude of the place of observation.

Examples.

I. Let the corrected altitude of the pole star be 46° 10′ N, observed 8h. 30′ before its passage over the meridian. Required the latitude ?

True altitude of the pole star	- -	46° 10′ N.
Equation from table 12 to 8h. 30′	- +	1 5
Latitude	- - - -	47 15 N.

II. At 1h. 10′ after the passage of the pole star over the meridian, its altitude corrected was 58° 51′ N. Required the latitude ?

True altitude of the pole star	- -	58° 51′ N.
Equation from table 12 to 1h. 10′	-	1 42
Latitude	- - -	57 9 N.

TABLE 12.

Difference of Altitude of Pole Star and Pole.

Argument. Distance of the Star from the Meridian, in Sidereal Time

Subtract.

Min.	0 Hour.	1 Hour.	2 Hours.	3 Hours.	4 Hours.	5 Hours.	
0	1° 46'.9	1° 43'.3	1° 32'.6	1° 15'.6	0° 53'.4	0° 27'.7	60
5	1 46.9	1 42.7	1 31.4	1 13.9	0 51.4	0 25.4	55
10	1 46.8	1 42.0	1 30.2	1 12.2	0 49.4	0 23.2	50
15	1 46 7	1 41.2	1 28.9	1 10.5	0 47.3	0 20.9	45
20	1 46.5	1 40.4	1 27.6	1 8.7	0 45.2	0 18.6	40
25	1 46.3	1 39.6	1 26.2	1 6.9	0 43.1	0 16.3	35
30	1 46.0	1 38.8	1 24.8	1 5.1	0 40.9	0 14.0	30
35	1 45.7	1 37.9	1 23.4	1 3.2	0 38.8	0 11.6	25
40	1 45.3	1 36.9	1 21.9	1 1.3	0 36.6	0 9.3	20
45	1 44.9	1 35.9	1 20.4	0 59.4	0 34.4	0 7.0	15
50	1 44.4	1 34.8	1 18.8	0 57.4	0 32.2	0 4.7	10
55	1 43.9	1 33.7	1 17.2	0 55.4	0 29.9	0 2.3	5
60	1 43.3	1 32.6	1 15.6	0 53.4	0 27.7	0 0.0	0
	11 Hours	10 Hours.	9 Hours.	8 Hours	7 Hours.	6 Hours.	Min.

Add.

Sun's Declination for the Years 1808, 1812, 1816, 1820.

Days	Jan.	Feb.	Mar.	April	May.	June.	July	Aug.	Sept	Oct.	Nov.	Dec.
	S.	S.	S.	N.	N.	N.	N.	N.	N.	S.	S.	S.
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
1	23 5	17 20	7 31	4 36	15 7	22 5	23 8	18 1	8 16	3 14	14 29	21 51
2	23 0	17 3	7 8	4 59	15 25	22 13	23 3	17 46	7 54	3 37	14 48	22 00
3	22 55	16 46	6 45	5 22	15 42	22 20	22 59	17 31	7 32	4 0	15 7	22 9
4	22 49	16 28	6 22	5 45	16 0	22 27	22 54	17 15	7 10	4 23	15 26	22 17
5	22 43	16 10	5 59	6 7	16 17	22 34	22 48	16 59	6 48	4 47	15 44	22 25
6	22 36	15 52	5 36	6 30	16 34	22 40	22 42	16 42	6 25	5 10	16 2	22 32
7	22 29	15 34	5 13	6 53	16 51	22 46	22 36	16 26	6 3	5 33	16 20	22 39
8	22 22	15 15	4 49	7 15	17 7	22 52	22 29	16 9	5 40	5 56	16 38	22 45
9	22 14	14 56	4 26	7 38	17 23	22 57	22 22	15 51	5 18	6 19	16 55	22 51
10	22 5	14 37	4 2	8 0	17 39	23 2	22 15	15 34	4 55	6 42	17 12	22 57
11	21 56	14 17	3 39	8 22	17 55	23 6	22 7	15 16	4 32	7 4	17 29	23 2
12	21 47	13 58	3 15	8 44	18 10	23 10	21 59	14 58	4 9	7 27	17 45	23 7
13	21 37	13 38	2 52	9 6	18 25	23 14	21 51	14 40	3 46	7 49	18 1	23 11
14	21 27	13 18	2 28	9 27	18 39	23 17	21 42	14 22	3 23	8 12	18 17	23 15
15	21 17	12 57	2 4	9 49	18 54	23 20	21 32	14 3	3 0	8 34	18 33	23 18
16	21 6	12 37	1 41	10 10	19 8	23 22	21 23	13 44	2 37	8 56	18 48	23 21
17	20 54	12 16	1 17	10 31	19 21	23 24	21 13	13 25	2 14	9 18	19 3	23 23
18	20 43	11 55	0 53	10 52	19 35	23 26	21 2	13 6	1 50	9 40	19 17	23 25
19	20 30	11 34	0 29	11 13	19 48	23 27	20 52	12 46	1 27	10 2	19 31	23 26
20	20 18	11 13	0 6	11 34	20 0	23 27	20 40	12 26	1 4	10 24	19 45	23 27
			S.						N.			
			N.						S.			
21	20 5	10 51	0 18	11 54	20 13	23 28	20 29	12 7	0 40	10 45	19 58	23 28
22	19 52	10 29	0 42	12 14	20 25	23 27	20 17	11 46	0 17	11 6	20 11	23 28
23	19 38	10 8	1 5	12 34	20 36	23 27	20 5	11 26	0 6	11 28	20 24	23 27
24	19 24	9 46	1 29	12 54	20 48	23 26	19 53	11 6	0 30	11 49	20 36	23 26
25	19 10	9 24	1 52	13 14	20 58	23 25	19 40	10 45	0 53	12 9	20 48	23 25
26	18 55	9 1	2 16	13 33	21 9	23 23	19 27	10 24	1 17	12 30	21 0	23 23
27	18 40	8 39	2 39	13 52	21 19	23 21	19 13	10 3	1 40	12 50	21 11	23 20
28	18 25	8 16	3 3	14 11	21 29	23 18	19 0	9 42	2 4	13 11	21 21	23 17
29	18 9	7 54	3 26	14 30	21 38	23 15	18 46	9 21	2 27	13 31	21 32	23 14
30	17 53		3 49	14 48	21 48	23 11	18 31	8 59	2 50	13 50	21 42	23 10
31	17 36		4 13		21 56		18 16	8 38		14 10		23 6

EXPLANATION AND USE OF THIS TABLE.

The Declination of the Sun is an arch of a meridian contained between its centre and the equinoctial, which arch is reckoned in degrees, minutes, &c.

In the first quadrant of the ecliptic, from about the 21st of March, to the 21st of June, the Sun's declination is North, and increasing; and in the third quadrant, between the 22d of September and 21st of December, the Sun's declination is South, and increasing. In the second quadrant of the ecliptic, from about the 21st of June to the 22d of September, the Sun's declination is North, and decreasing; and in the fourth quadrant, between the 21st of December and the 21st of March, the Sun's declination is South, and decreasing; which will be readily perceived by inspecting the table.

In this table, the Sun's declination is given, from the year 1808 to 1823 inclusive, calculated for the instant of noon, each day, at

Sun's Declination for the Years 1809, 1813, 1817, 1821.

Days	Jan.	Feb.	Mar	April	May.	June.	July.	Aug.	Sept	Oct	Nov.	Dec.
	S.	S.	S.	N.	N.	N.	N.	N.	N.	S.	S.	S
	° '	° '	° '	° '	° '	° '	° '	° '	° '	° '	° '	° '
1	23 2	17 7	7 37	4 30	15 2	22 3	23 9	18 6	8 22	3 7	14 24	21 49
2	22 56	16 50	7 14	4 53	15 20	22 11	23 5	17 50	8 0	3 31	14 43	21 58
3	22 51	16 33	6 51	5 16	15 38	22 18	23 0	17 35	7 38	3 54	15 2	22 7
4	22 45	16 15	6 28	5 39	15 55	22 26	22 55	17 19	7 16	4 17	15 21	22 15
5	22 38	15 57	6 5	6 2	16 13	22 32	22 50	17 3	6 54	4 40	15 40	22 23
6	22 31	15 39	5 45	6 24	16 30	22 39	22 44	16 47	6 31	5 4	15 58	22 30
7	22 24	15 20	5 19	6 47	16 45	22 45	22 38	16 30	6 9	5 27	16 16	22 37
8	22 16	15 1	4 55	7 9	17 3	22 51	22 31	16 13	5 46	5 50	16 33	22 44
9	22 8	14 42	4 32	7 32	17 19	22 56	22 25	15 56	5 24	6 13	16 51	22 50
10	21 59	14 23	4 9	7 54	17 35	23 1	22 17	15 39	5 1	6 35	17 8	22 56
11	21 50	14 3	3 41	8 16	17 51	23 5	22 10	15 21	4 38	6 58	17 25	23 1
12	21 40	13 43	3 21	8 38	18 6	23 9	22 2	15 3	4 15	7 21	17 41	23 6
13	21 30	13 23	2 58	9 0	18 21	23 13	21 53	14 45	3 52	7 43	17 57	23 10
14	21 20	13 3	2 34	9 22	18 36	23 16	21 44	14 27	3 29	8 6	18 13	23 14
15	21 9	12 42	2 11	9 43	18 50	23 19	21 35	14 8	3 6	8 28	18 29	23 17
16	20 58	12 22	1 47	10 5	19 4	23 22	21 25	13 49	2 43	8 50	18 44	23 20
17	20 46	12 1	1 23	10 26	19 18	23 24	21 16	13 30	2 20	9 13	18 59	23 23
18	20 34	11 40	0 59	10 47	19 31	23 25	21 5	13 11	1 57	9 35	19 13	23 25
19	20 22	11 18	0 36	11 8	19 44	23 27	20 55	12 52	1 33	9 56	19 27	23 26
20	20 9	10 57	0 12 S.	11 28	19 57	23 27	20 44	12 32	1 10 N.	10 18	19 41	23 27
			N.						S.			
21	19 56	10 35	0 12	11 49	20 10	23 28	20 32	12 12	0 47	10 40	19 55	23 28
22	19 42	10 13	0 35	12 9	20 22	23 28	20 21	11 52	0 23	11 1	20 08	23 28
23	19 28	9 52	0 59	12 29	20 33	23 27	20 9	11 52	0 0	11 22	29 21	23 27
24	19 14	9 29	1 23	12 49	20 45	23 26	19 56	11 11	0 24	11 43	20 33	23 26
25	18 59	9 7	1 46	13 9	20 56	23 25	19 44	10 51	0 47	12 4	20 45	23 25
26	18 44	8 45	2 10	13 28	21 6	23 23	19 30	10 30	1 10	12 25	20 57	23 23
27	18 29	8 22	2 33	13 47	21 17	23 21	19 17	10 9	1 34	12 45	21 8	23 21
28	18 13	8 0	2 57	14 6	21 27	23 19	19 3	9 48	1 57	13 5	21 19	23 18
29	17 57		3 20	14 25	21 36	23 16	18 49	9 27	2 21	13 25	21 29	23 15
30	17 41		3 43	14 44	21 45	23 13	18 35	9 5	2 44	13 45	21 39	23 11
31	17 24		4 7		21 54		18 21	8 44		14 5		23 7

the Meridian of Greenwich, or the meridian, at which we begin to reckon the Longitude. It is to be taken out with the month at the top, and the day in the left hand column, at the same time, noting whether it be North, or South, as expressed at the top of each column. The declination being here given to the nearest minute, it will be found sufficiently exact for the most common and useful problems, wherein it is concerned.

The sun's declination is necessary to find the latitude, whether at sea or land, from the meridian altitude observed ; it is also requisite for finding the latitude from two altitudes observed with the interval of time measured by a watch ; it serves for computing the sun's azimuth, having his altitude and the latitude of the place given, in order to find the variation of the compass ; it is required, jointly with the latitude of the place and the sun's horary angle, to compute his altitude, if neglected to be observed at the time of taking the moon's distance from the sun for finding the longitude, being useful to facilitate the calculation of the effect

Sun's Declination for the Years 1810, 1814, 1818, 1822.

Days.	Jan.	Feb.	Mar.	April	May.	June.	July.	Aug.	Sept	Oct.	Nov.	Dec
	S.	S.	S	N.	N.	N	N	N.	N	S.	S.	S.
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
1	23 3	17 12	7 43	4 24	14 57	22 1	23 10	18 9	8 27	3 2	14 20	21 46
2	22 58	16 54	7 20	4 47	15 16	22 9	23 6	17 54	8 5	3 25	14 39	21 56
3	22 52	16 37	6 57	5 10	15 33	22 16	23 1	17 39	7 43	3 48	14 58	22 5
4	22 46	16 19	6 34	5 33	15 51	22 24	22 56	17 23	7 21	4 12	15 17	22 13
5	22 40	16 1	6 11	5 56	16 8	22 31	22 51	17 7	6 59	4 35	15 35	22 21
6	22 33	15 43	5 48	6 19	16 26	22 37	22 46	16 51	6 37	4 58	15 53	22 28
7	22 26	15 24	5 24	6 41	16 42	22 44	22 39	16 34	6 14	5 21	16 11	22 36
8	22 18	15 6	5 1	7 4	16 59	22 49	22 33	16 17	5 52	5 44	16 29	22 42
9	22 10	14 47	4 38	7 26	17 15	22 55	22 26	16 0	5 29	6 7	16 46	22 49
10	22 1	14 27	4 14	7 49	17 31	23 00	22 19	15 43	5 7	6 30	17 4	22 54
11	21 52	14 8	3 51	8 11	17 47	23 4	22 11	15 25	4 44	6 53	17 20	23 00
12	21 42	13 48	3 27	8 33	18 2	23 8	22 3	15 8	4 21	7 15	17 37	23 5
13	21 33	13 28	3 4	8 55	18 17	23 12	21 55	14 50	3 58	7 38	17 53	23 9
14	21 22	13 8	2 40	9 16	18 32	23 16	21 46	14 31	3 35	8 0	18 9	23 13
15	21 11	12 47	2 16	9 38	18 47	23 19	21 37	14 13	3 12	8 23	18 25	23 16
16	21 0	12 27	1 53	9 59	19 1	23 21	21 28	13 54	2 49	8 45	18 40	23 19
17	20 49	12 6	1 29	10 20	19 14	23 23	21 18	13 35	2 26	9 7	18 55	23 22
18	20 37	11 45	1 5	10 42	19 28	23 25	21 8	13 16	2 2	9 29	19 10	23 24
19	20 25	11 24	0 42	11 2	19 41	23 26	20 57	12 56	1 39	9 51	19 24	23 26
20	20 12	11 2	0 18	11 23	19 54	23 27	20 46	12 37	1 16	10 13	19 38	23 27
			S.						N.			
			N.						S.			
21	19 59	10 41	0 6	11 44	20 6	23 28	20 35	12 17	0 52	10 34	19 51	23 27
22	19 45	10 19	0 29	12 4	20 19	23 28	20 23	11 57	0 29	10 56	20 5	23 28
23	19 31	9 57	0 53	12 24	20 30	23 27	20 12	11 37	0 6	11 17	20 18	23 27
24	19 17	9 35	1 17	12 44	20 42	23 27	19 59	11 16	0 18	11 38	20 30	23 27
25	19 3	9 13	1 40	13 4	20 53	23 25	19 47	10 56	0 41	11 59	20 42	23 25
26	18 48	8 50	2 4	13 23	21 4	23 24	19 34	10 35	1 5	12 20	20 54	23 24
27	18 33	8 28	2 27	13 43	21 14	23 22	19 20	10 14	1 28	12 40	21 5	23 22
28	18 17	8 5	2 51	14 2	21 24	23 19	19 7	9 53	1 52	13 0	21 16	23 19
29	18 1		3 14	14 21	21 34	23 17	18 53	9 32	2 15	13 21	21 27	23 16
30	17 45		3 37	14 39	21 43	23 13	18 39	9 10	2 38	13 40	21 37	23 12
31	17 28		4 1		21 52		18 24	8 49		14 0		23 8

of refraction and parallax upon the distance ; it is also necessary to calculate the apparent time from an obsered altitude of the sun at a distance from the meridian, the latitude being given ; or to compute the time of the sun's setting or rising ; which, though a less accurate method than the former of obtaining the time, may yet be useful when that cannot be had. For any of these purposes the sun's declination must be found to the time given nearly, reduced to the meridian of *Greenwich*, making proportion according to its daily increase, or decrease, by the help of table 14, as in the following examples.

1st Required the Sun's Declination at noon in New-York, in Longitude 74° 8′ West, on the 1st of April, 1811.

Dec. for April 1st, 1811, at Greenwich, in Tab. 13 = 4° 18′ N.
Equation for Long. Table 14. = + 4 50″

Required Declination = 4° 22′ 50″. N.

Sun's Declination for the Years 1811, 1815, 1819, 1823.

Days	Jan	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept	Oct.	Nov.	Dec.
	S.	S.		N.	N.	N.	N.	N.	N.	S.	S.	S.
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
1	23 4	17 16	7 48	4 18	14 53	21 59	23 11	18 13	8 32	2 56	14 15	21 44
2	22 59	16 59	7 25	4 42	15 11	22 7	23 7	17 58	8 11	3 19	14 34	21 53
3	22 54	16 41	7 3	5 5	15 29	22 15	23 2	17 42	7 49	3 43	14 53	22 2
4	22 48	16 24	6 40	5 28	15 47	22 22	22 58	17 27	7 27	4 6	15 12	22 11
5	22 41	16 6	6 17	5 50	16 4	22 29	22 52	17 11	7 5	4 29	15 31	22 19
6	22 35	15 47	5 53	6 13	16 21	22 36	22 47	16 55	6 42	4 52	15 49	22 27
7	22 27	15 29	5 30	6 36	16 38	22 42	22 41	16 38	6 20	5 15	16 7	22 34
8	22 20	15 10	5 7	6 58	16 55	22 48	22 35	16 22	5 57	5 38	16 25	22 41
9	22 12	14 51	4 43	7 21	17 11	22 53	22 28	16 4	5 35	6 1	16 42	22 47
10	22 3	14 32	4 20	7 43	17 27	22 59	22 21	15 47	5 12	6 24	16 59	22 53
11	21 54	14 13	3 57	8 5	17 43	23 3	22 13	15 30	4 49	6 47	17 16	22 58
12	21 45	13 53	3 33	8 27	17 58	23 7	22 5	15 12	4 27	7 10	17 33	23 3
13	21 35	13 33	3 9	8 49	18 14	23 11	21 57	14 54	4 4	7 32	17 49	23 8
14	21 25	13 13	2 46	9 11	18 28	23 15	21 49	14 36	3 41	7 55	18 5	23 12
15	21 14	12 52	2 22	9 33	18 43	23 18	21 40	14 17	3 17	8 17	18 21	23 16
16	21 3	12 32	1 59	9 54	18 57	23 21	21 30	13 58	2 54	8 40	18 36	23 19
17	20 52	12 11	1 35	10 15	19 11	23 23	21 20	13 40	2 31	9 2	18 51	23 21
18	20 40	11 50	1 11	10 36	19 25	23 25	21 10	13 20	2 8	9 24	19 6	23 24
19	20 28	11 29	0 47	10 57	19 38	23 26	21 0	13 1	1 45	9 46	19 21	23 25
20	20 15	11 7	0 24	11 18	19 51	23 27	20 49	12 41	1 21	10 7	19 35	23 27
			S.						N.			
			N.						S.			
21	20 2	10 46	0 0	11 39	20 3	23 28	20 38	12 22	0 58	10 29	19 48	23 27
22	19 49	10 24	0 24	11 59	20 16	23 28	20 26	12 2	0 35	10 50	20 2	23 28
23	19 35	10 2	0 47	12 19	20 28	23 27	20 14	11 41	0 11	11 12	20 14	23 28
24	19 21	9 40	1 11	12 39	20 39	23 27	20 2	11 21	0 12	11 33	20 27	23 27
25	19 6	9 18	1 35	12 59	20 50	23 26	19 50	11 1	0 36	11 54	20 39	23 26
26	18 52	8 56	1 58	13 19	21 1	23 24	19 37	10 40	0 59	12 15	20 51	23 24
27	18 36	8 33	2 22	13 38	21 12	23 22	19 24	10 19	1 23	12 35	21 2	23 22
28	18 21	8 11	2 45	13 57	21 22	23 20	19 10	9 58	1 46	12 55	21 13	23 20
29	18 5		3 9	14 16	21 32	23 17	18 56	9 37	2 9	13 16	21 24	23 17
30	17 49		3 32	14 35	21 41	23 14	18 43	9 15	2 33	13 36	21 34	23 13
31	17 32		3 55		21 50		18 28	8 54		13 55		23 9

N. B. To find the equations in Table 14,—seek the Sun's declination to the nearest degree in the top line of the table ; then, under this declination and against the given Lon. in the left hand column, is found the equation for Lon. and in the same column with the dec. and against the given time from Noon, in the right hand column, is found the equation for time ; both which equations must be added, or subtracted, according to the directions at the head of the Table.

2d Required the Sun's Declination on the 1st of May, 1811, at 5 h. 48 min. P. M. in Longitude 72° W.

Dec. May 1st, 1811, table 13.	=	14° 53′ N.
Equat. for Lon.	=	+ 3 41″
Equat. for Time	=	+ 4 27
Reduced Dec.		15 1 8 N.

When Sun's dec. increases.		When Sun's dec. decreases.	
Add in W. lon.	Add af. noon.	Sub. in W. lon.	Sub. af. noon.
Sub. in E. lon.	Sub. be. noon.	Add in E. lon.	Add be. noon.

Lon.	Sun's Declination.								Ti. fr. noon.
	0°	2°	4°	6°	8°	9°	10°	11°	
0°	0′ 0″	0′ 0″	0′ 0″	0′ 0″	0′ 0″	0′ 0″	0′ 0″	0′ 0″	0h 0m
3	0 12	0 12	0 12	0 11	0 11	0 15	0 11	0 11	0 12
6	0 24	0 24	0 24	0 23	0 23	0 22	0 22	0 21	0 24
9	0 35	0 35	0 35	0 34	0 34	0 33	0 32	0 32	0 36
12	0 47	0 47	0 47	0 46	0 45	0 44	0 43	0 42	0 48
15	0 59	0 59	0 58	0 57	0 56	0 55	0 54	0 53	1 0
18	1 11	1 10	1 10	1 9	1 7	1 6	1 5	1 3	1 12
21	1 22	1 22	1 22	1 21	1 18	1 17	1 16	1 14	1 24
24	1 34	1 34	1 33	1 32	1 29	1 28	1 27	1 24	1 36
27	1 46	1 45	1 44	1 43	1 41	1 39	1 38	1 35	1 48
30	1 58	1 57	1 56	1 54	1 51	1 49	1 48	1 45	2 0
33	2 10	2 10	2 8	2 6	2 3	2 1	1 59	1 55	2 12
36	2 22	2 21	2 19	2 17	2 14	2 12	2 10	2 6	2 24
39	2 33	2 32	2 31	2 39	2 25	2 23	2 20	2 16	2 36
42	2 45	2 44	2 43	2 40	2 36	2 34	2 31	2 27	2 48
45	2 57	2 56	2 54	2 51	2 47	2 44	2 41	2 38	3 0
48	3 9	3 8	3 6	3 3	2 59	2 55	2 52	2 49	3 12
51	3 20	3 19	3 18	3 15	3 10	3 6	3 3	3 0	3 24
54	3 32	3 31	3 30	3 26	3 21	3 17	3 14	3 10	3 36
57	3 43	3 42	3 41	3 37	3 32	3 28	3 25	3 21	3 48
60	3 55	3 54	3 52	3 48	3 43	3 39	3 35	3 31	4 0
63	4 7	4 6	4 4	4 0	3 54	3 50	3 46	3 42	4 12
66	4 19	4 18	4 16	4 12	4 5	4 1	3 57	3 52	4 24
69	4 31	4 30	4 27	4 23	4 16	4 12	4 8	4 3	4 36
72	4 43	4 42	4 39	4 34	4 27	4 23	4 19	4 13	4 48
75	4 54	4 53	4 50	4 45	4 38	4 34	4 29	4 23	5 0
78	5 6	5 5	5 2	4 57	4 50	4 45	4 40	4 34	5 12
81	5 18	5 17	5 14	5 9	5 1	4 56	4 51	4 44	5 24
84	5 30	5 28	5 26	5 20	5 12	5 7	5 2	4 55	5 36
87	5 41	5 40	5 37	5 31	5 23	5 18	5 13	5 5	5 48
90	5 53	5 52	5 48	5 42	5 34	5 29	5 23	5 16	6 0
93	6 5	6 4	6 0	5 54	5 46	5 41	5 34	5 27	6 12
96	6 17	6 15	6 12	6 6	5 57	5 52	5 45	5 37	6 24
99	6 28	6 27	6 23	6 17	6 8	6 3	5 56	5 48	6 36
102	6 40	6 39	6 35	6 28	6 19	6 14	6 7	5 58	6 48
105	6 52	6 51	6 46	6 39	6 30	6 24	6 17	6 9	7 0
108	7 4	7 2	6 58	6 51	6 41	6 35	6 28	6 19	7 12
111	7 15	7 14	7 10	7 3	6 52	6 46	6 39	6 30	7 24
114	7 27	7 26	7 22	7 15	7 3	6 57	6 50	6 40	7 36
117	7 39	7 37	7 33	7 26	7 14	7 8	7 1	6 51	7 48
120	7 51	7 49	7 44	7 37	7 25	7 18	7 11	7 1	8 0
123	8 3	8 1	7 56	7 49	7 37	7 29	7 22	7 12	8 12
126	8 14	8 13	8 8	8 0	7 48	7 40	7 33	7 22	8 24
129	8 26	8 24	8 20	8 11	7 59	7 51	7 43	7 33	8 36
132	8 38	8 36	8 31	8 22	8 10	8 2	7 54	7 43	8 48
135	8 50	8 48	8 42	8 33	8 21	8 13	8 4	7 54	9 0
138	9 1	8 59	8 54	8 45	8 33	8 24	8 15	8 5	9 12
141	9 13	9 11	9 6	8 57	8 44	8 35	8 26	8 15	9 24
144	9 25	9 23	9 18	9 8	8 55	8 46	8 37	8 26	9 36
147	9 37	9 35	9 29	9 19	9 6	8 57	8 48	8 36	9 48
150	9 48	9 45	9 40	9 30	9 17	9 8	8 58	8 47	10 0
153	10 0	9 57	9 52	9 42	9 28	9 19	9 9	8 57	10 12
156	10 12	10 9	10 4	9 54	9 39	9 30	9 20	9 8	10 24
159	10 24	10 21	10 16	10 5	9 50	9 41	9 31	9 18	10 36
162	10 36	10 33	10 27	10 16	10 1	9 52	9 42	9 29	10 48
165	10 47	10 44	10 38	10 27	10 12	10 3	9 52	9 39	11 0
168	10 59	10 56	10 50	10 39	10 24	10 14	10 3	9 50	11 12
171	11 11	11 8	11 2	10 51	10 35	10 25	10 14	10 0	11 24
174	11 23	11 20	11 14	11 3	10 46	10 36	10 25	10 11	11 36
177	11 34	11 31	11 25	11 14	10 57	10 47	10 36	10 21	11 48
180	11 46	11 43	11 37	11 25	11 8	10 58	10 46	10 32	12 0

When Sun's dec. increases.		When Sun's dec. decreases.	
Add in W. lon.	Add af. noon.	Sub. in W. lon.	Sub. af. noon.
Sub. in E. lon.	Sub. be. noon	Add in E. lon.	Add be. noon.

Lon.	Sun's Declination.								time fr. Noon.
	12°	13°	14°	15°	16°	17°	18°	19°	
0°	0′ 0″	0′ 0″	0′ 0″	0′ 0″	0′ 0″	0′ 0″	0′ 0″	0′ 0″	0h 0m
3	0 10	0 10	0 9	0 9	0 9	0 8	0 8	0 7	0 12
6	0 20	0 20	0 18	0 18	0 18	0 16	0 16	0 14	0 24
9	0 31	0 30	0 28	0 27	0 27	0 24	0 24	0 21	0 36
12	0 41	0 40	0 38	0 37	0 36	0 32	0 31	0 28	0 48
15	0 51	0 50	0 48	0 46	0 44	0 41	0 39	0 35	1 0
18	1 1	1 0	0 58	0 55	0 53	0 49	0 46	0 42	1 12
21	1 12	1 9	1 7	1 5	1 2	0 57	0 54	0 49	1 24
24	1 22	1 19	1 17	1 14	1 11	1 5	1 2	0 56	1 36
27	1 32	1 29	1 27	1 23	1 20	1 14	1 10	1 3	1 48
30	1 43	1 39	1 36	1 32	1 28	1 23	1 18	1 11	2 0
33	1 53	1 49	1 46	1 42	1 37	1 31	1 25	1 18	2 12
36	2 3	1 59	1 56	1 51	1 46	1 39	1 33	1 25	2 24
39	2 14	2 9	2 5	2 1	1 55	1 47	1 41	1 32	2 36
42	2 24	2 19	2 15	2 10	2 4	1 56	1 49	1 39	2 48
45	2 34	2 29	2 24	2 19	2 12	2 5	1 57	1 46	3 0
48	2 44	2 39	2 34	2 28	2 21	2 13	2 4	1 53	3 12
51	2 55	2 49	2 44	2 38	2 30	2 21	2 12	2 0	3 24
54	3 5	2 59	2 53	2 47	2 39	2 29	2 20	2 7	3 36
57	3 15	3 9	3 3	2 56	2 48	2 38	2 28	2 15	3 48
60	3 25	3 19	3 13	3 5	2 56	2 47	2 36	2 23	4 0
63	3 35	3 29	3 22	3 14	3 5	2 55	2 43	2 29	4 12
66	3 46	3 39	3 32	3 23	3 14	3 3	2 51	2 36	4 24
69	3 56	3 49	3 42	3 32	3 23	3 11	2 59	2 43	4 36
72	4 6	3 59	3 51	3 41	3 32	3 19	3 7	2 50	4 48
75	4 16	4 9	4 1	3 51	3 40	3 28	3 15	2 58	5 0
78	4 27	4 19	4 11	4 0	3 49	3 36	3 22	3 5	5 12
81	4 37	4 29	4 20	4 9	3 58	3 44	3 30	3 12	5 24
84	4 47	4 39	4 30	4 18	4 7	3 52	3 38	3 19	5 36
87	4 58	4 49	4 40	4 27	4 16	4 1	3 46	3 26	5 48
90	5 8	4 59	4 49	4 37	4 25	4 10	3 54	3 34	6 0
93	5 18	5 9	4 59	4 46	4 34	4 18	4 1	3 41	6 12
96	5 28	5 19	5 9	4 55	4 43	4 26	4 9	3 48	6 24
99	5 39	5 29	5 18	5 5	4 52	4 34	4 17	3 55	6 36
102	5 49	5 39	5 28	5 14	5 0	4 43	4 25	4 2	6 48
105	5 59	5 49	5 37	5 23	5 8	4 52	4 33	4 9	7 0
108	6 9	5 59	5 47	5 32	5 17	5 0	4 40	4 16	7 12
111	6 20	6 9	5 56	5 42	5 26	5 8	4 48	4 23	7 24
114	6 30	6 19	6 6	5 51	5 35	5 16	4 56	4 30	7 36
117	6 40	6 29	6 15	6 1	5 44	5 25	5 4	4 38	7 48
120	6 51	6 39	6 25	6 10	5 53	5 34	5 12	4 46	8 0
123	7 1	6 49	6 35	6 19	6 2	5 42	5 19	4 53	8 12
126	7 11	6 59	6 44	6 28	6 11	5 50	5 27	5 0	8 24
129	7 22	7 9	6 54	6 37	6 19	5 58	5 35	5 7	8 36
132	7 32	7 18	7 4	6 46	6 28	6 6	5 43	5 14	8 48
135	7 42	7 28	7 13	6 56	6 36	6 15	5 51	5 21	9 0
138	7 52	7 38	7 23	7 5	6 45	6 23	5 58	5 28	9 12
141	8 3	7 48	7 33	7 14	6 54	6 31	6 6	5 35	9 24
144	8 13	7 58	7 42	7 23	7 3	6 39	6 14	5 42	9 36
147	8 23	8 8	7 52	7 32	7 12	6 48	6 22	5 49	9 48
150	8 33	8 18	8 2	7 42	7 21	6 57	6 30	5 57	10 0
153	8 43	8 28	8 12	7 51	7 30	7 5	6 37	6 4	10 12
156	8 54	8 38	8 21	8 0	7 39	7 13	6 45	6 11	10 24
159	9 4	8 48	8 31	8 10	7 48	7 21	6 53	6 18	10 36
162	9 14	8 58	8 41	8 19	7 57	7 29	7 1	6 25	10 48
165	9 24	9 8	8 50	8 28	8 5	7 38	7 9	6 32	11 0
168	9 35	9 18	9 0	8 38	8 14	7 46	7 16	6 39	11 12
171	9 45	9 28	9 10	8 47	8 23	7 54	7 24	6 46	11 24
174	9 55	9 38	9 19	8 57	8 32	8 3	7 32	6 53	11 36
177	10 6	9 48	9 24	9 6	8 41	8 12	7 40	7 1	11 48
180	10 16	9 58	9 38	9 15	8 49	8 21	7 48	7 5	12 0

When Sun's dec. increases.		When Sun's dec. decreases.	
Add in W. lon. Sub. in E. lon.	Add aft. noon. Sub. bef. noon.	Sub. in W. lon. Add in E. lon.	Sub. aft. noon Add bef. noon.

Lon.	Sun's Declination.									time fr Noon.
	19°30'	20°	20°30'	21°	21°30'	22°	22°30'	23°	23°15'	
0°	0'0"	0'0"	0'0"	0'0"	0'0"	0'0"	0'0"	0'0"	0'0"	0h0m
3	0 7	0 6	0 6	0 5	0 5	0 4	0 3	0 2	0 2	0 12
6	0 13	0 12	0 11	0 10	0 9	0 8	0 6	0 4	0 4	0 24
9	0 20	0 18	0 17	0 15	0 14	0 12	0 10	0 7	0 5	0 36
12	0 27	0 25	0 23	0 21	0 19	0 16	0 14	0 9	0 7	0 48
15	0 34	0 32	0 29	0 27	0 24	0 21	0 18	0 12	0 9	1 0
18	0 40	0 38	0 35	0 32	0 29	0 25	0 21	0 14	0 10	1 12
21	0 47	0 44	0 41	0 38	0 34	0 29	0 24	0 17	0 12	1 24
24	0 54	0 50	0 47	0 44	0 39	0 34	0 28	0 19	0 14	1 36
27	1 1	0 57	0 53	0 50	0 44	0 39	0 32	0 22	0 15	1 48
30	1 8	1 4	0 59	0 55	0 49	0 43	0 36	0 25	0 17	2 0
33	1 14	1 10	1 4	1 0	0 53	0 47	0 39	0 27	0 19	2 12
36	1 21	1 16	1 10	1 5	0 58	0 51	0 42	0 30	0 20	2 24
39	1 28	1 22	1 16	1 10	1 3	0 55	0 46	0 32	0 22	2 36
42	1 35	1 29	1 22	1 16	1 8	0 59	0 50	0 34	0 24	2 48
45	1 42	1 36	1 28	1 22	1 13	1 4	0 54	0 36	0 25	3 0
48	1 48	1 42	1 33	1 27	1 18	1 8	0 57	0 39	0 27	3 12
51	1 55	1 48	1 39	1 32	1 23	1 12	1 0	0 42	0 29	3 24
54	2 2	1 54	1 45	1 38	1 28	1 16	1 3	0 44	0 30	3 36
57	2 9	2 1	1 52	1 44	1 33	1 21	1 7	0 47	0 32	3 48
60	2 16	2 8	1 59	1 49	1 39	1 26	1 11	0 49	0 34	4 0
63	2 22	2 14	2 4	1 54	1 43	1 30	1 14	0 51	0 35	4 12
66	2 29	2 20	2 10	1 59	1 48	1 34	1 17	0 54	0 37	4 24
69	2 36	2 26	2 16	2 4	1 53	1 38	1 21	0 56	0 39	4 36
72	2 43	2 33	2 21	2 10	1 58	1 42	1 25	0 59	0 40	4 48
75	2 50	2 40	2 27	2 16	2 3	1 47	1 29	1 1	0 42	5 0
78	2 56	2 46	2 33	2 21	2 8	1 51	1 32	1 4	0 44	5 12
81	3 3	2 52	2 39	2 26	2 13	1 55	1 35	1 6	0 45	5 24
84	3 10	2 58	2 45	2 32	2 18	1 59	1 39	1 9	0 47	5 36
87	3 17	3 5	2 52	2 38	2 23	2 4	1 43	1 11	0 49	5 48
90	3 24	3 12	2 59	2 44	2 28	2 9	1 47	1 14	0 50	6 0
93	3 30	3 18	3 4	2 49	2 32	2 13	1 50	1 16	0 52	6 12
96	3 37	3 24	3 9	2 54	2 37	2 17	1 53	1 19	0 54	6 24
99	3 44	3 30	3 15	2 59	2 42	2 21	1 57	1 21	0 55	6 36
102	3 51	3 37	3 21	3 5	2 47	2 25	2 1	1 24	0 57	6 48
105	3 58	3 44	3 27	3 11	2 52	2 30	2 5	1 26	0 59	7 0
108	4 4	3 50	3 33	3 16	2 57	2 34	2 9	1 29	1 0	7 12
111	4 11	3 56	3 39	3 21	3 2	2 38	2 12	1 31	1 2	7 24
114	4 18	4 2	3 46	3 27	3 7	2 43	2 16	1 34	1 4	7 36
117	4 25	4 9	3 52	3 33	3 12	2 48	2 20	1 37	1 5	7 48
120	4 32	4 16	3 59	3 39	3 17	2 53	2 23	1 39	1 7	8 0
123	4 38	4 22	4 4	3 44	3 22	2 57	2 26	1 41	1 9	8 12
126	4 45	4 28	4 10	3 49	3 27	3 1	2 29	1 44	1 10	8 24
129	4 52	4 34	4 16	3 54	3 32	3 5	2 33	1 46	1 12	8 36
132	4 59	4 41	4 22	3 59	3 37	3 9	2 36	1 49	1 14	8 48
135	5 6	4 48	4 28	4 5	3 42	3 13	2 40	1 51	1 15	9 0
138	5 12	4 54	4 34	4 10	3 47	3 17	2 43	1 54	1 17	9 12
141	5 19	5 0	4 40	4 15	3 52	3 21	2 46	1 56	1 19	9 24
144	5 26	5 6	4 46	4 21	3 57	3 26	2 50	1 59	1 20	9 36
147	5 33	5 13	4 52	4 27	4 2	3 30	2 54	2 1	1 22	9 48
150	5 40	5 20	4 58	4 33	4 7	3 35	2 58	2 4	1 24	10 0
153	5 46	5 26	5 3	4 38	4 11	3 39	3 1	2 6	1 25	10 12
156	5 53	5 32	5 9	4 43	4 16	3 43	3 4	2 9	1 27	10 24
159	6 0	5 38	5 15	4 48	4 21	3 47	3 8	2 11	1 29	10 36
162	6 7	5 45	5 21	4 54	4 26	3 51	3 12	2 13	1 30	10 48
165	6 14	5 52	5 26	5 0	4 31	3 56	3 16	2 15	1 32	11 0
168	6 20	5 58	5 32	5 6	4 36	4 0	3 19	2 17	1 34	11 12
171	6 27	6 4	5 38	5 11	4 41	4 4	3 22	2 20	1 35	11 24
174	6 34	6 10	5 44	5 17	4 46	4 9	3 26	2 22	1 37	11 36
177	6 41	6 17	5 51	5 23	4 51	4 14	3 30	2 25	1 39	11 48
180	6 48	6 24	5 58	5 29	4 56	4 19	3 34	2 28	1 40	12 0

I.

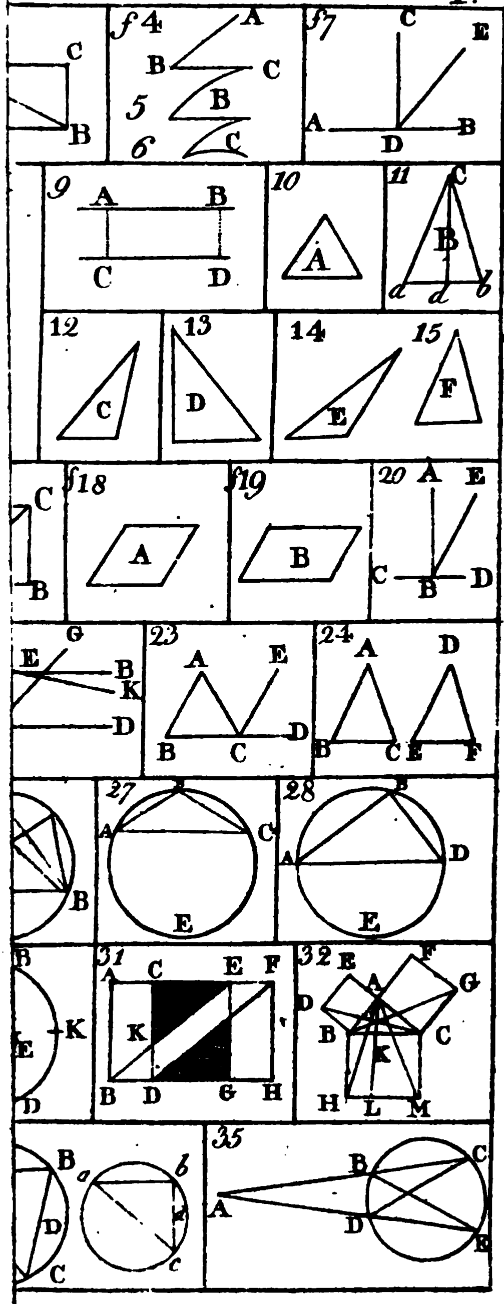
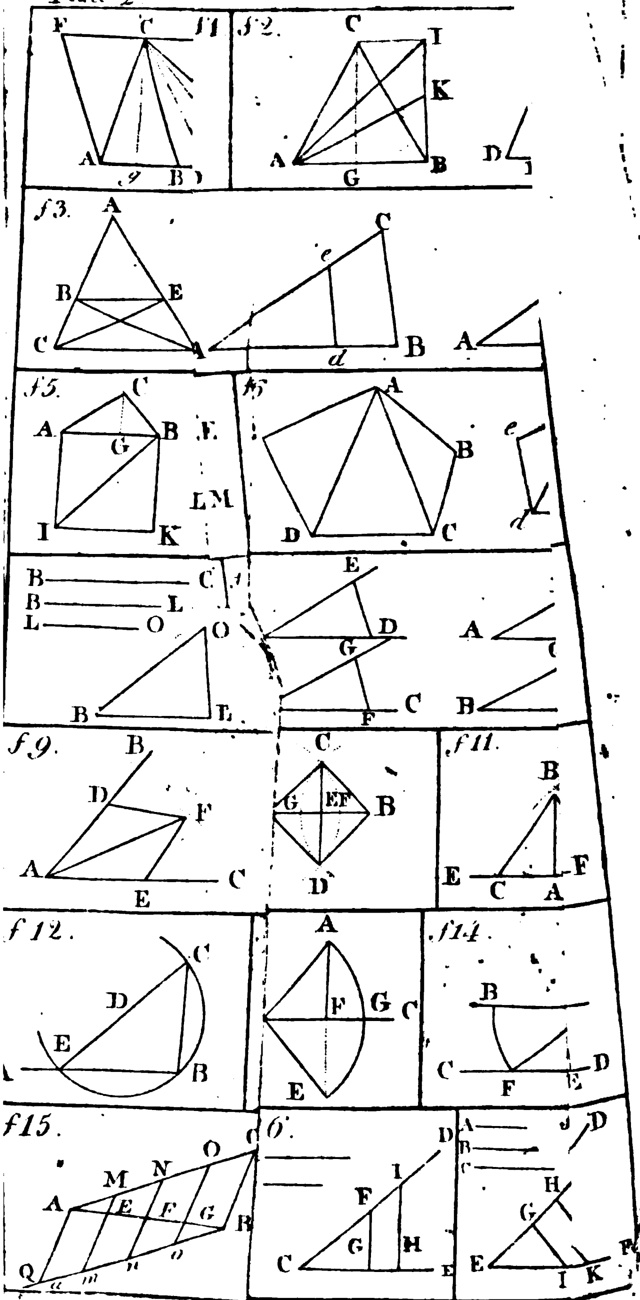
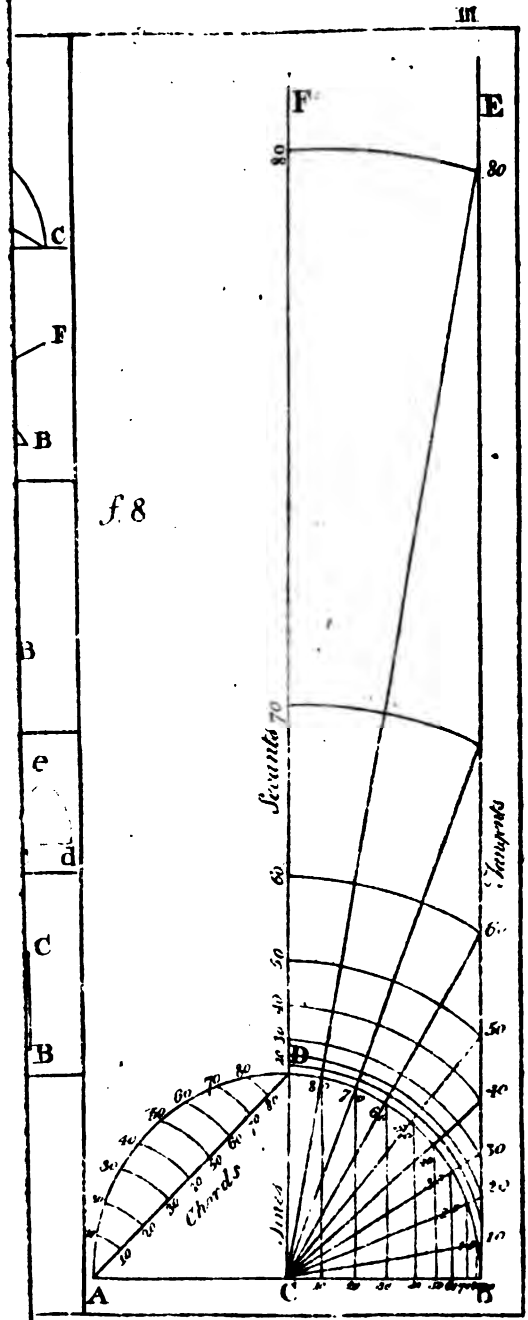


Plate 2

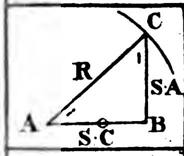
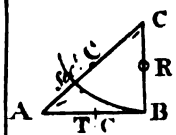
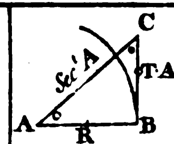
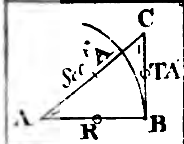
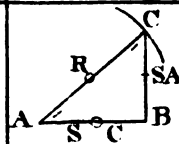
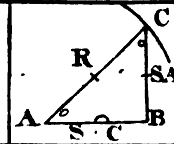
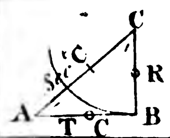
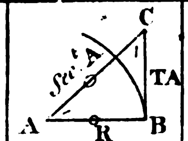
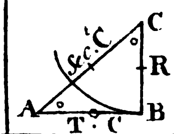



F
E
80
70
60
50
40
30
20
10
D
C
B
F
B
e
d
Secants
Tangents
Chords
Sines
A
C

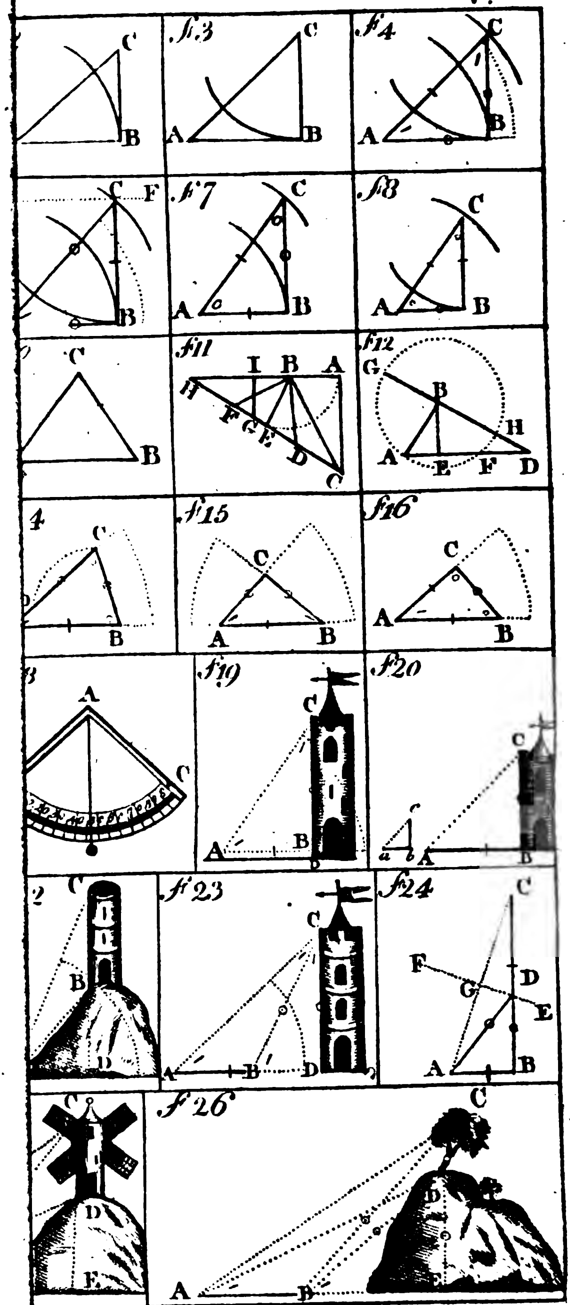
f. 8

Plate 4. IV.

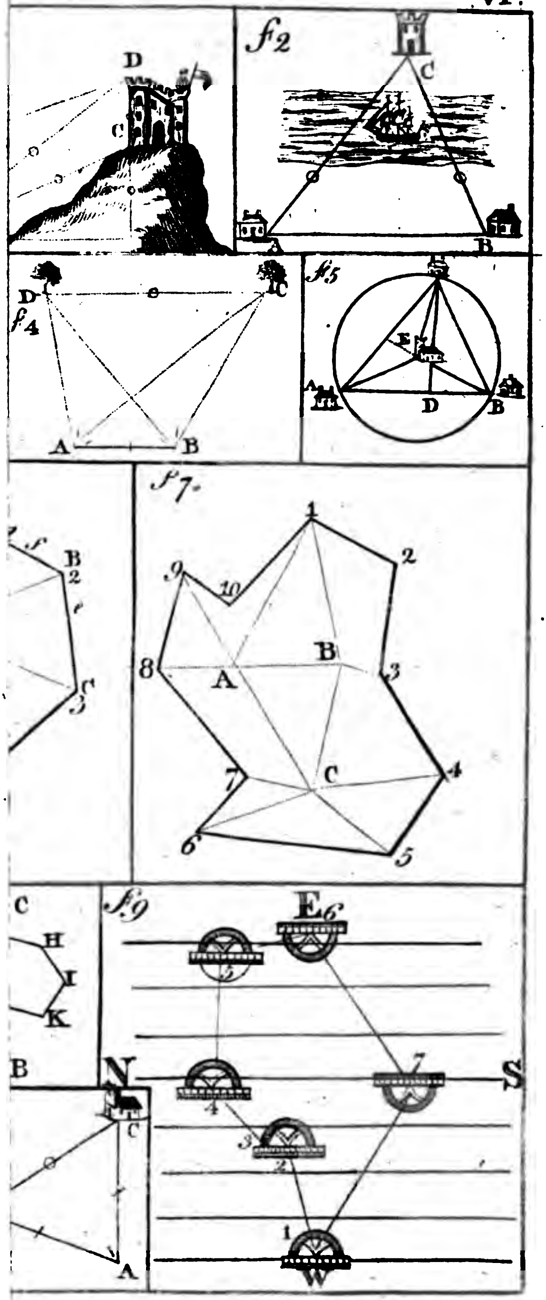
The Proportions for the Solution of 6 Cases of Right Angled Plain Triangles

	Case 1. R : AC :: SA : BC R : AC :: SC : AB		TC : AB :: R : BC TC : AB :: Sec C : AC		AB : R :: AC : Sec A R : AB :: TA : BC
	Sec A : AC :: R : AB Sec A : AC :: TA : BC		Case 3. SA : BC :: R : AC SA : BC :: SC : AB		Case 5. AC : R :: BC : SA R : AC :: SC : AB
	Sec C : AC :: R : BC Sec C : AC :: TC : AB		TA : BC :: R : AB TA : BC :: Sec A : AC		BC : R :: AC : Sec C R : BC :: TC : AB

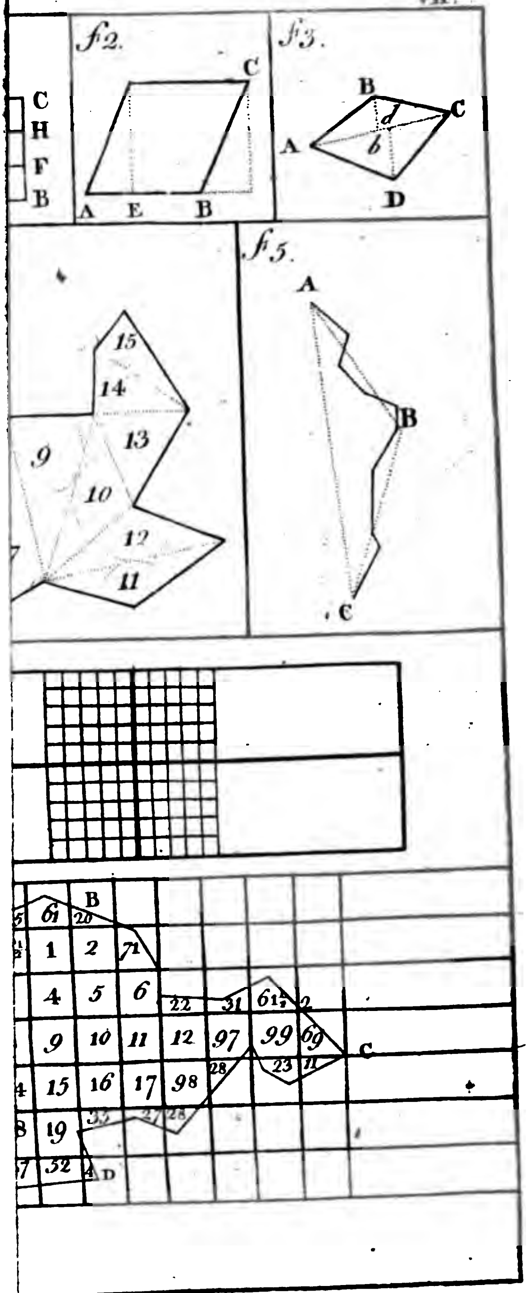
V.



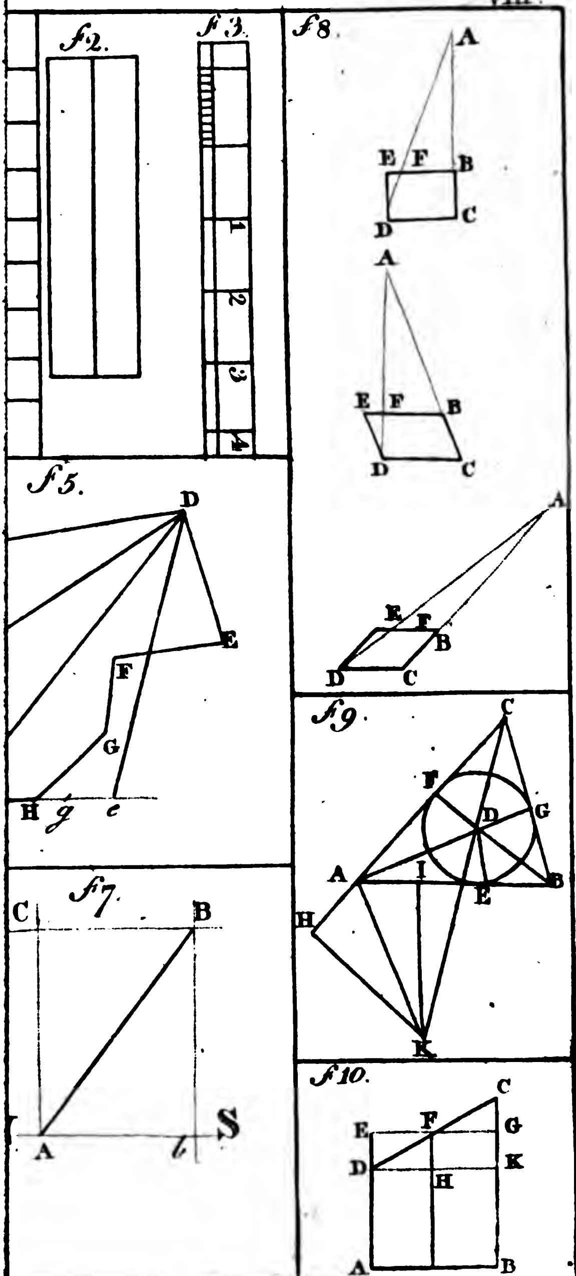
VI.



D
C
f2
C
A
B
D
C
f4
A
B
f5
E
A
D
B
B
2
3
f7
1
2
9
10
8
A
B
3
7
C
4
6
5
C
H
I
K
B
N
C
A
f9
E6
5
4
3
2
7
S
1
W

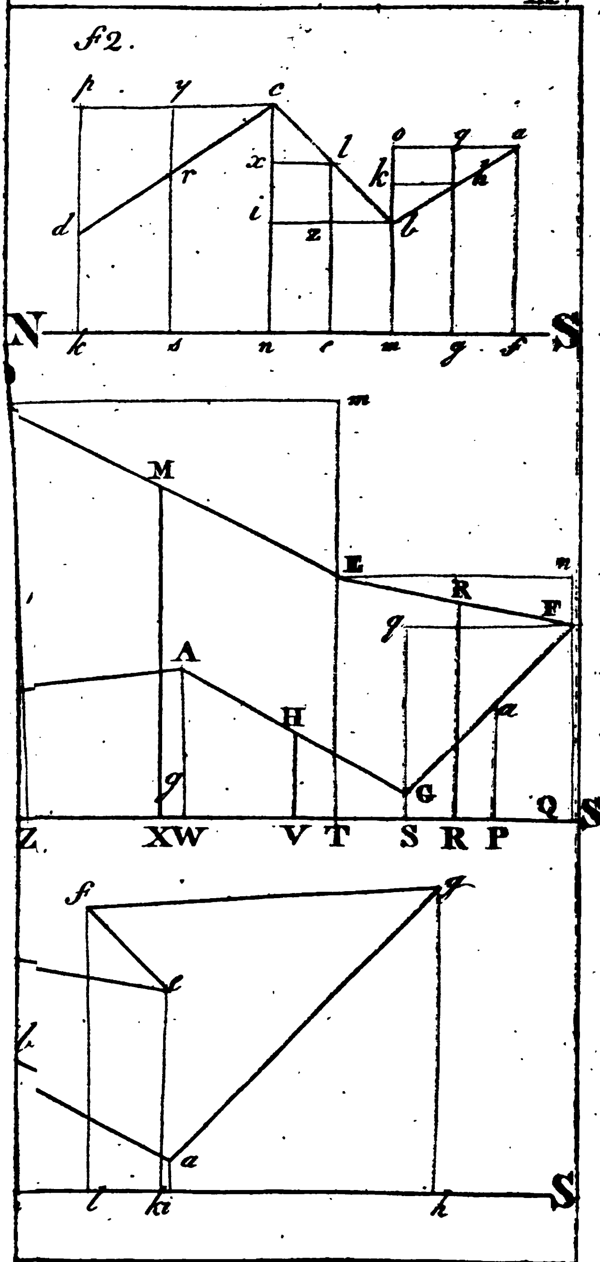

C
H
F
B
f 2.
A
E
B
C
f 3.
A
B
C
D
d
b
f 5.
A
B
C
15
14
13
9
10
12
11
B
61
20
1
2
71
4
5
6
22
31
9
10
11
12
97
99
69
C
23
15
16
17
98
28
19
33
27
28
32
D

VIII.

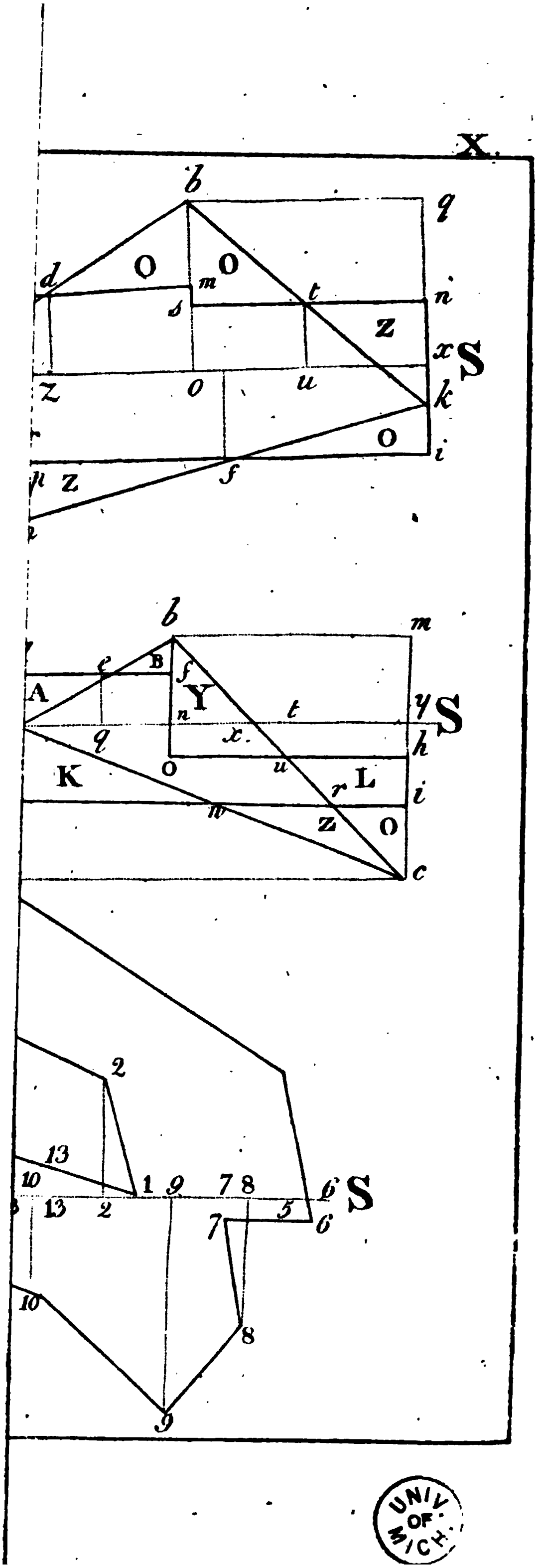


f2.
f3.
1
2
3
4
f8.
A
E F B
D C
A
E F B
D C
A
E F B
D C
f5.
D
E
F
G
H g e
f9.
C
F
D G
A I B
E
H
K
f7.
C B
A b S
f10.
C
E F G
D K
H
A B

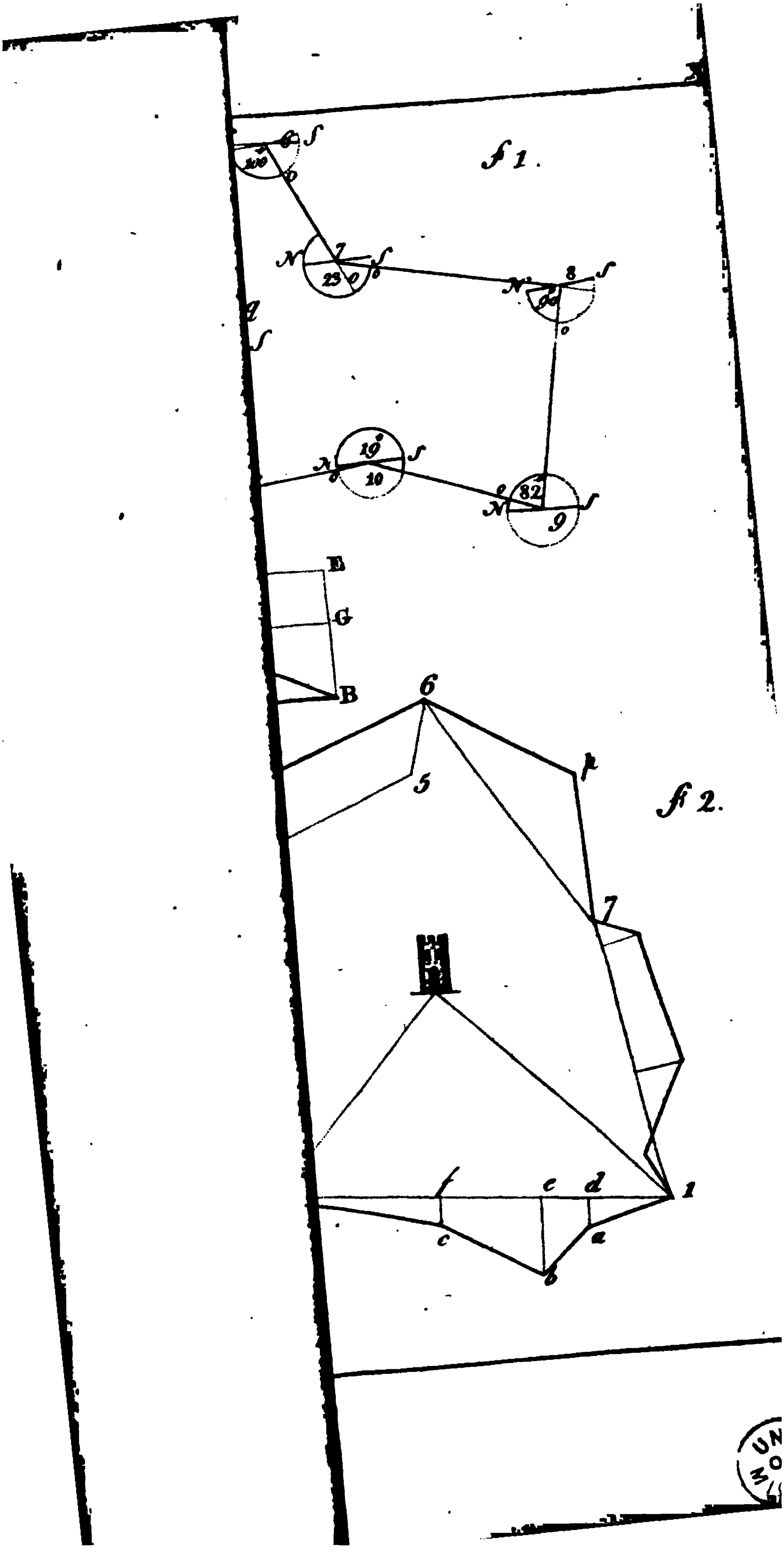
IX.


f2.
p y c
o q a
x l
r k h
d i b
z
N k s n r m g f S
m
M
E n
R
F
q
A
H a
g G Q
Z XW V T S R P S
f g
e
a
l ki h S

X.



b
q
d
O
m
O
s
t
n
Z
x
S
Z
o
u
k
O
i
Z
f
b
m
e
B
f
A
Y
n
t
y
S
q
x
h
o
u
K
r
L
i
w
Z
O
c
2
13
10
1
9
7
8
6
S
13
2
5
7
6
10
8
9


f 1.
6
100
7
23
8
9
10
19
82
q
E
G
B
6
5
p
7
f 2.
1
a
b
c
d
e
f

XII.

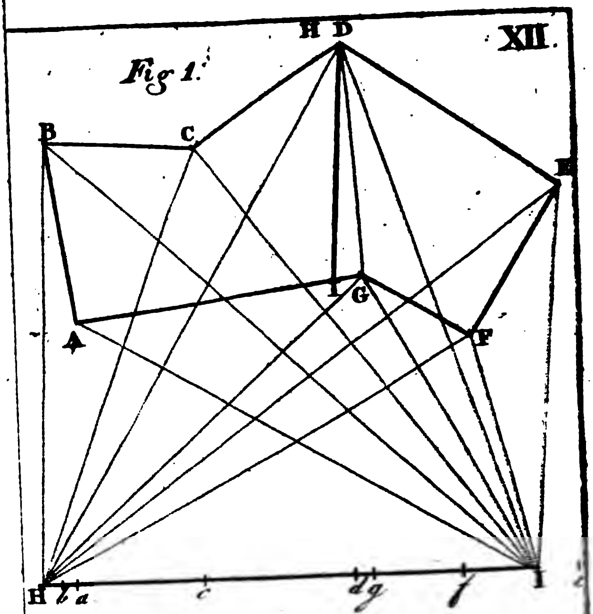


Fig 1.

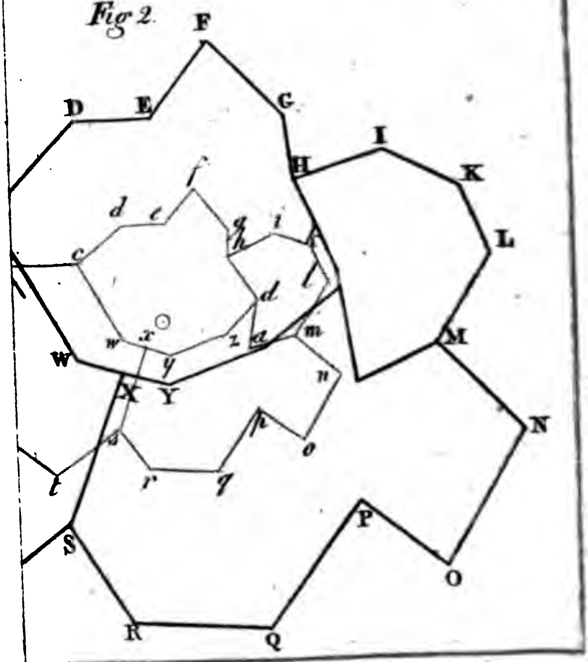
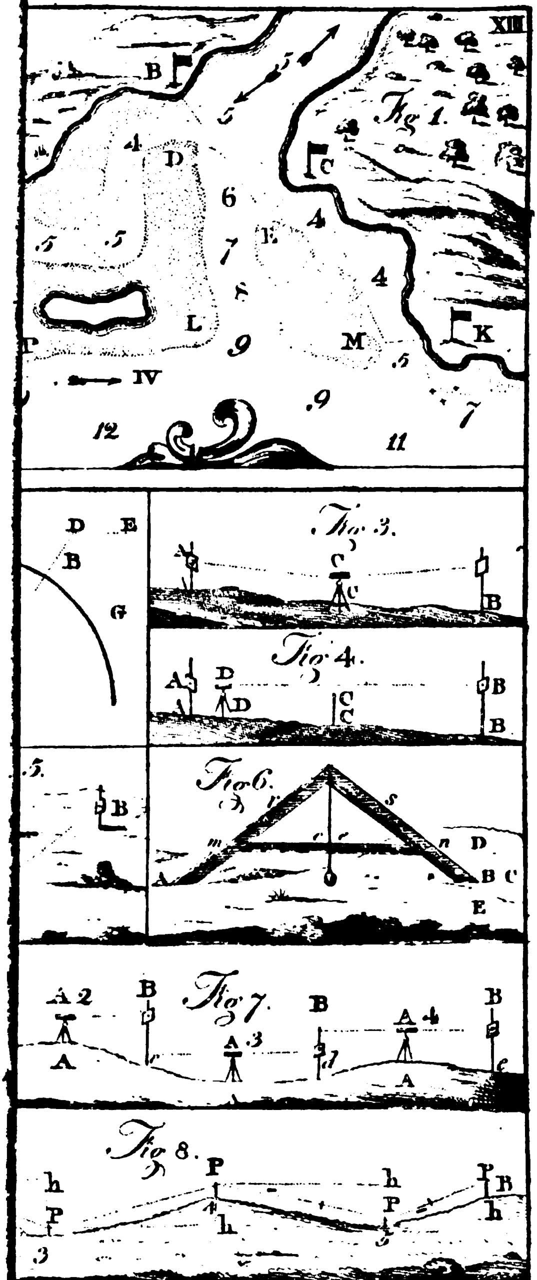


Fig 2.


XIII
Fig. 1.
B
C
D
E
K
L
M
IV
Fig. 3.
C
B
D
E
B
G
Fig. 4.
A
D
C
B
5.
B
Fig. 6.
D
B C
E
Fig. 7.
A 2
A 3
A 4
B
A
Fig. 8.
P
h
B